ATLAS

IPP AGM
17th June 2007

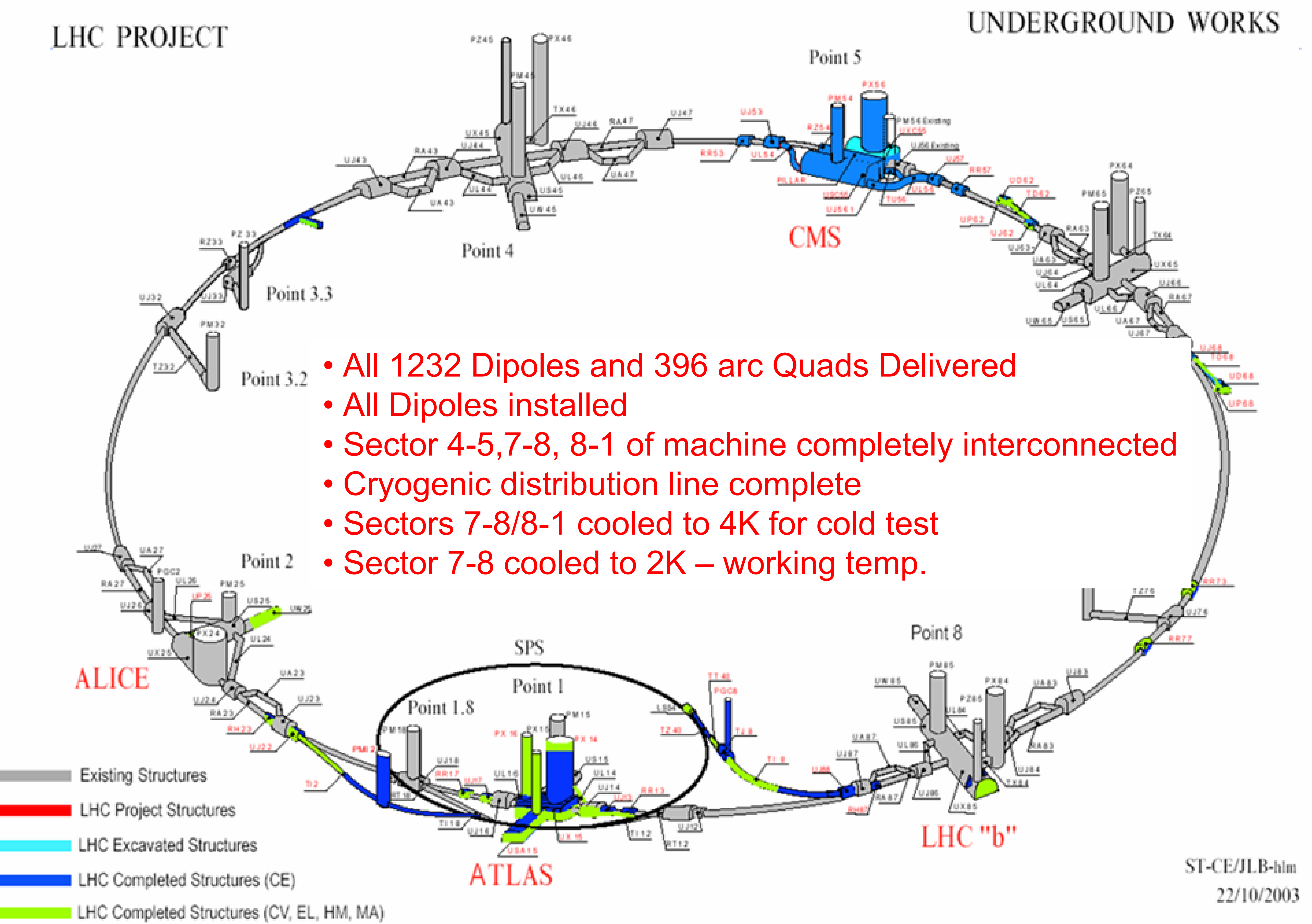
Status: LHC, ATLAS

Next Two Years

Next Five - Ten Years

Next Ten - Twenty Years

R. S. Orr

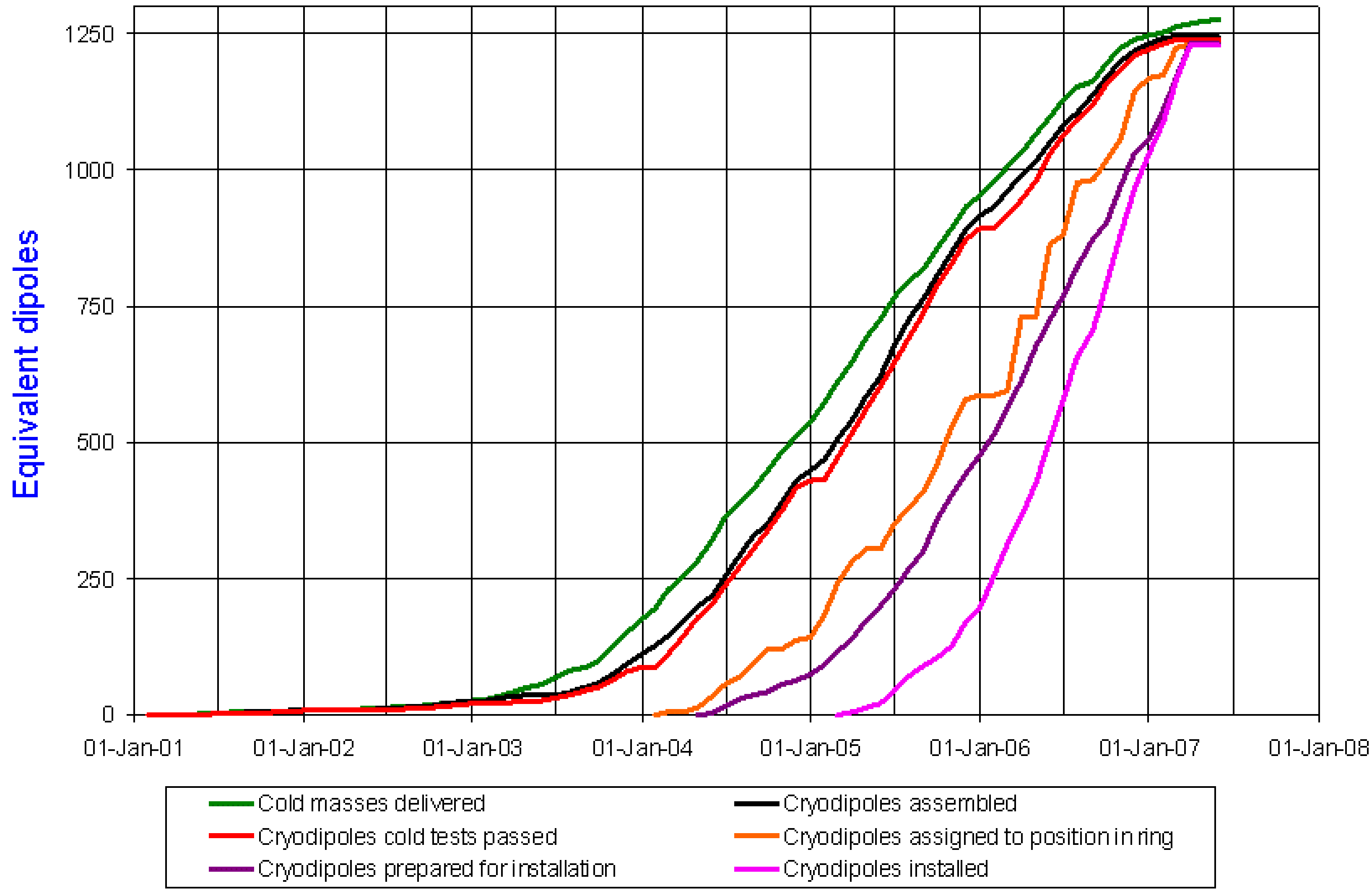


- All 1232 Dipoles and 396 arc Quads Delivered
- All Dipoles installed
- Sector 4-5,7-8, 8-1 of machine completely interconnected
- Cryogenic distribution line complete
- Sectors 7-8/8-1 cooled to 4K for cold test
- Sector 7-8 cooled to 2K – working temp.

LHC Progress Dashboard

Accelerator Technology Department

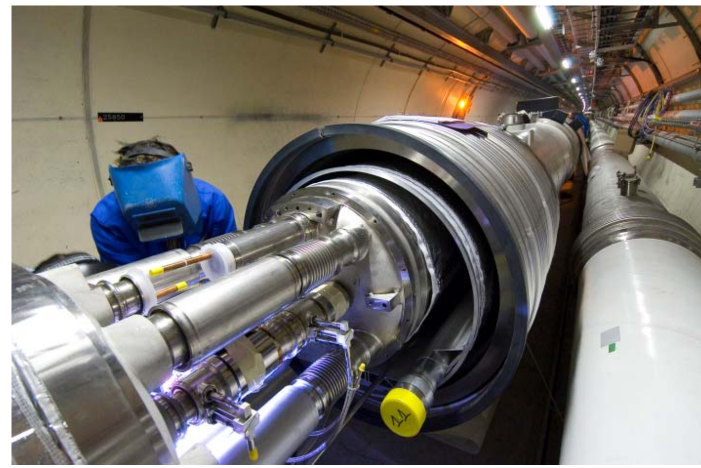
Cryodipole overview



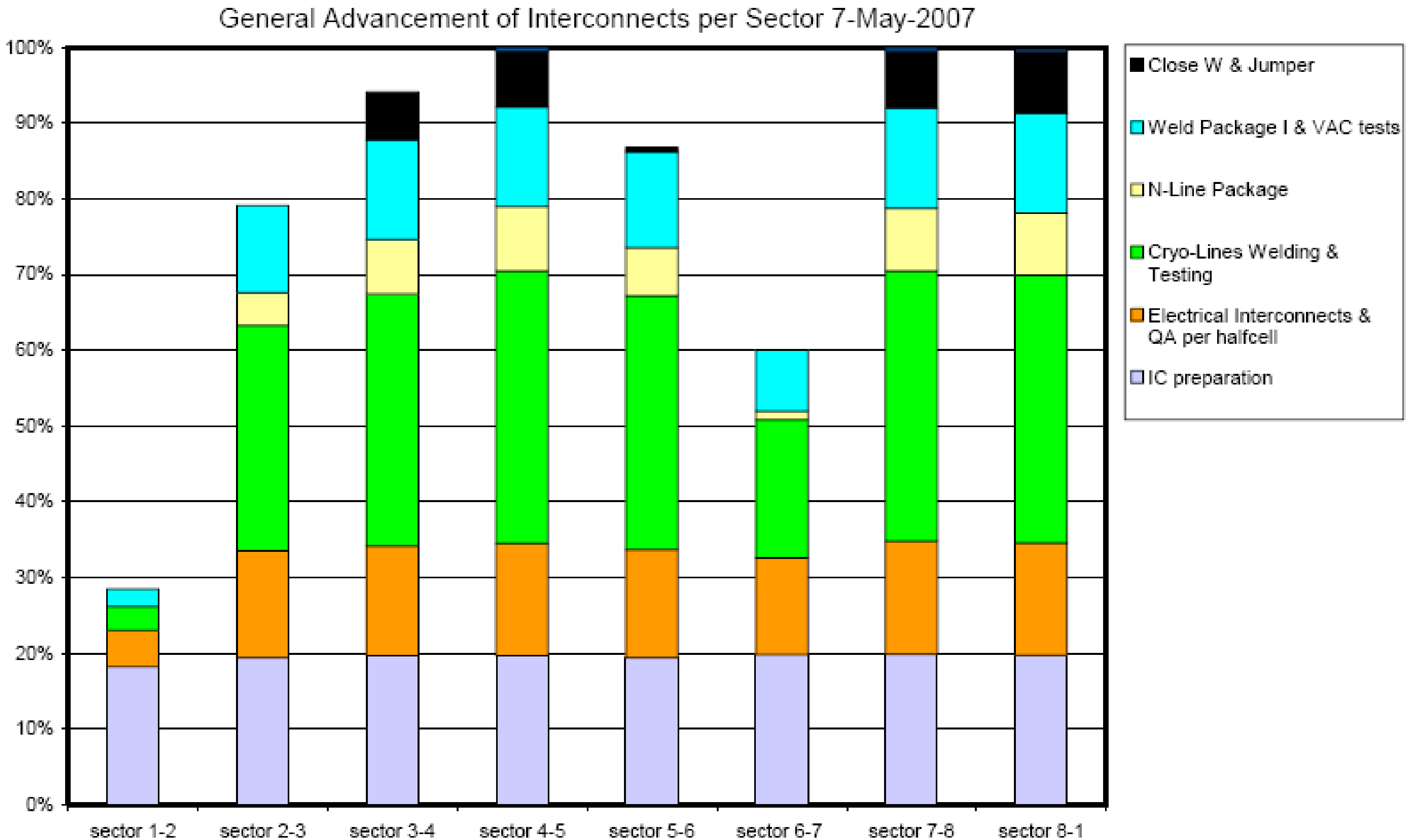
Updated 31 May 2007

Data provided by D. Tommasini AT-MCS, L. Bottura AT-MTM

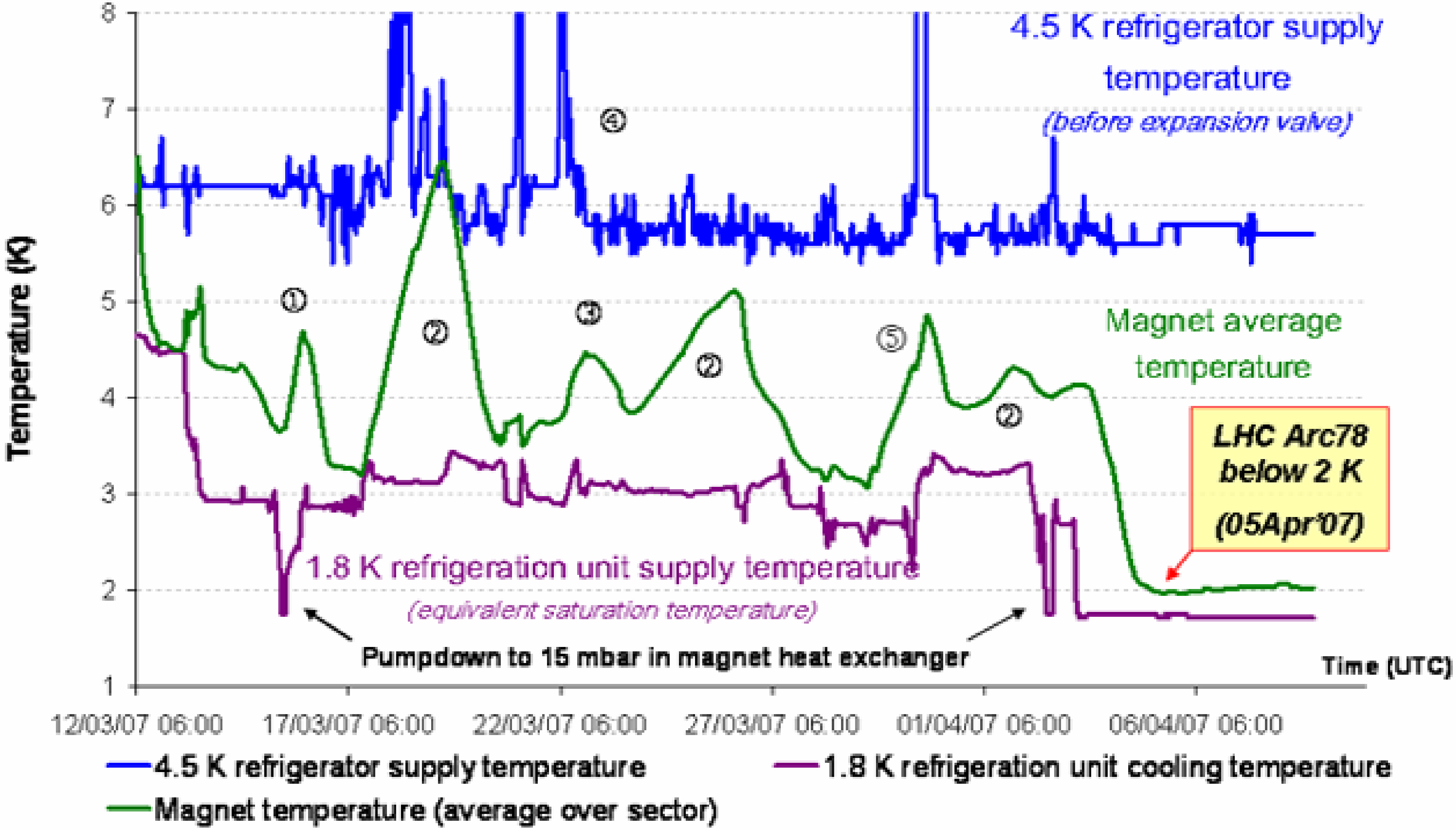
Underground
Last Dipole April 2007



Magnet Interconnections



LHC sector 78 - First cooldown - Phase 4.5 K to 1.9 K

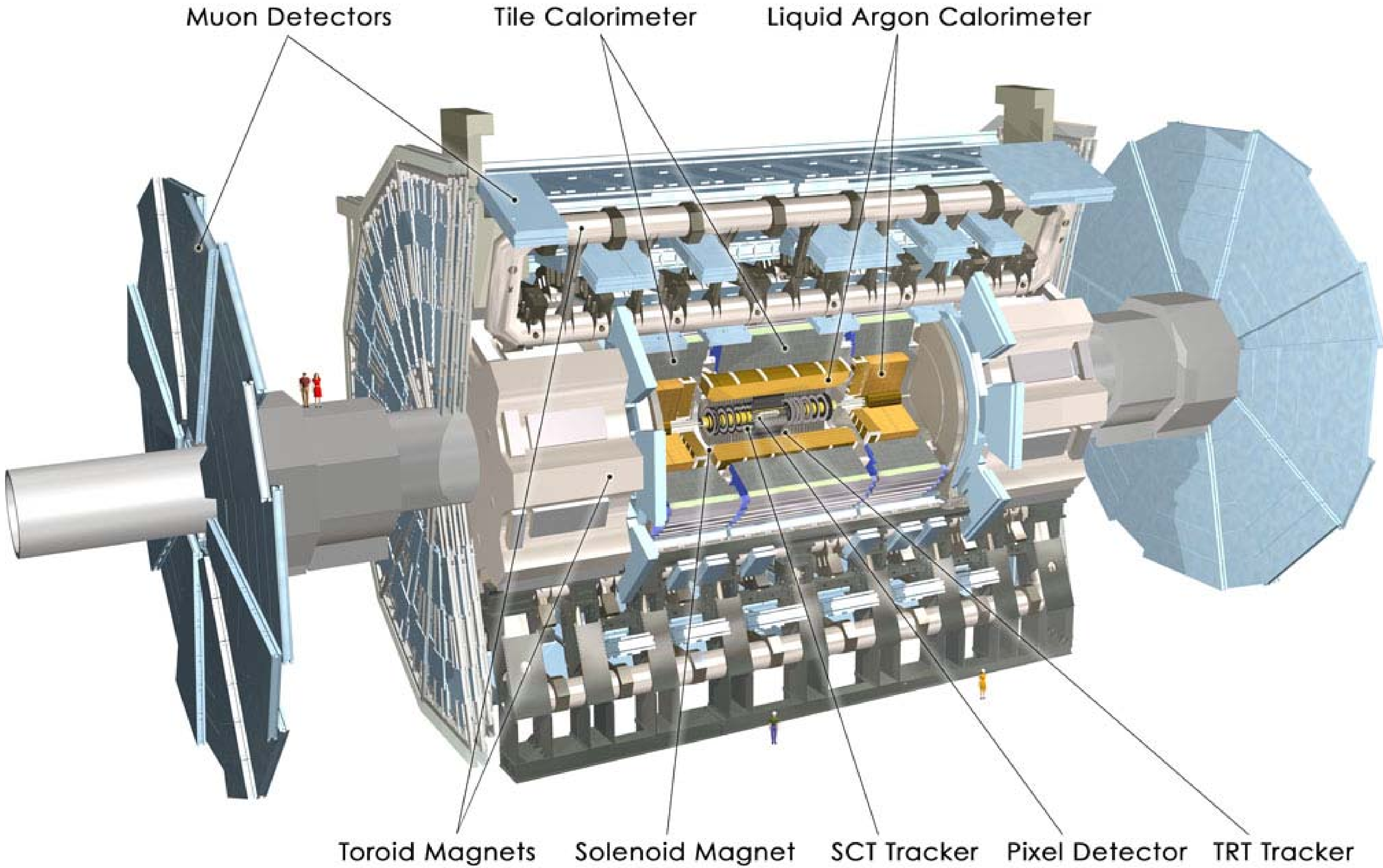


① Tuning of cold compressors & turbines with temporary stop of magnet cooling
② Stop of active cooling in weekend with only on call activity limited to secure hardware
③ Stop of magnet cooling for logic improvement in 1.8K refrigeration unit
④ Random emergency stop in cryogenic surface building with stop of sector 78 cooling
⑤ micro-electrical stop followed by utility stops

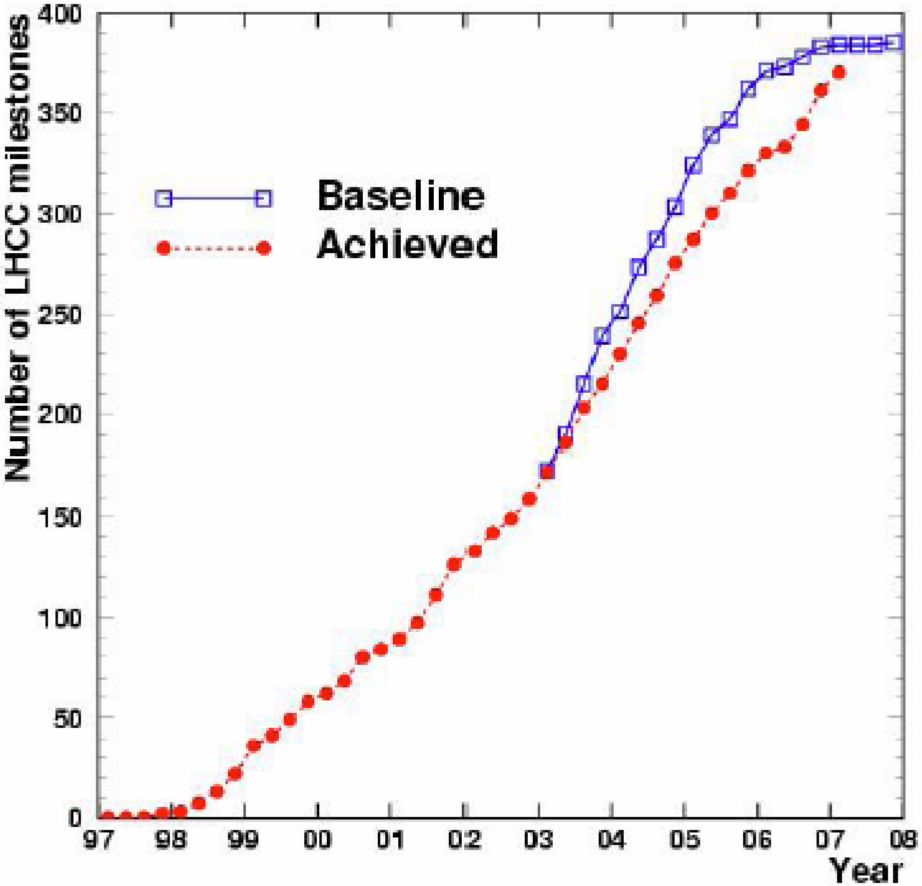
General Schedule

- Dec 2007 engineering run not possible - delays in installation and equipment commissioning.
- Schedule being reassessed, accounting for inner triplet repairs and their impact on sector commissioning
  - All technical systems commissioned to 7 TeV operation, and machine closed April 2008
  - Beam commissioning starts May 2008
  - First collisions at 14 TeV c.m. July 2008
  - Pilot run pushed to 156 bunches for reaching 10^{32} $cm^{-2}.s^{-1}$ by end 2008
  - winter 2008-09 shutdown to complete collimation system and dilution kickers, thus allowing high intensity operation
- No provision in schedule for major mis-haps, e.g. additionnel warm-up/cool-down of sector

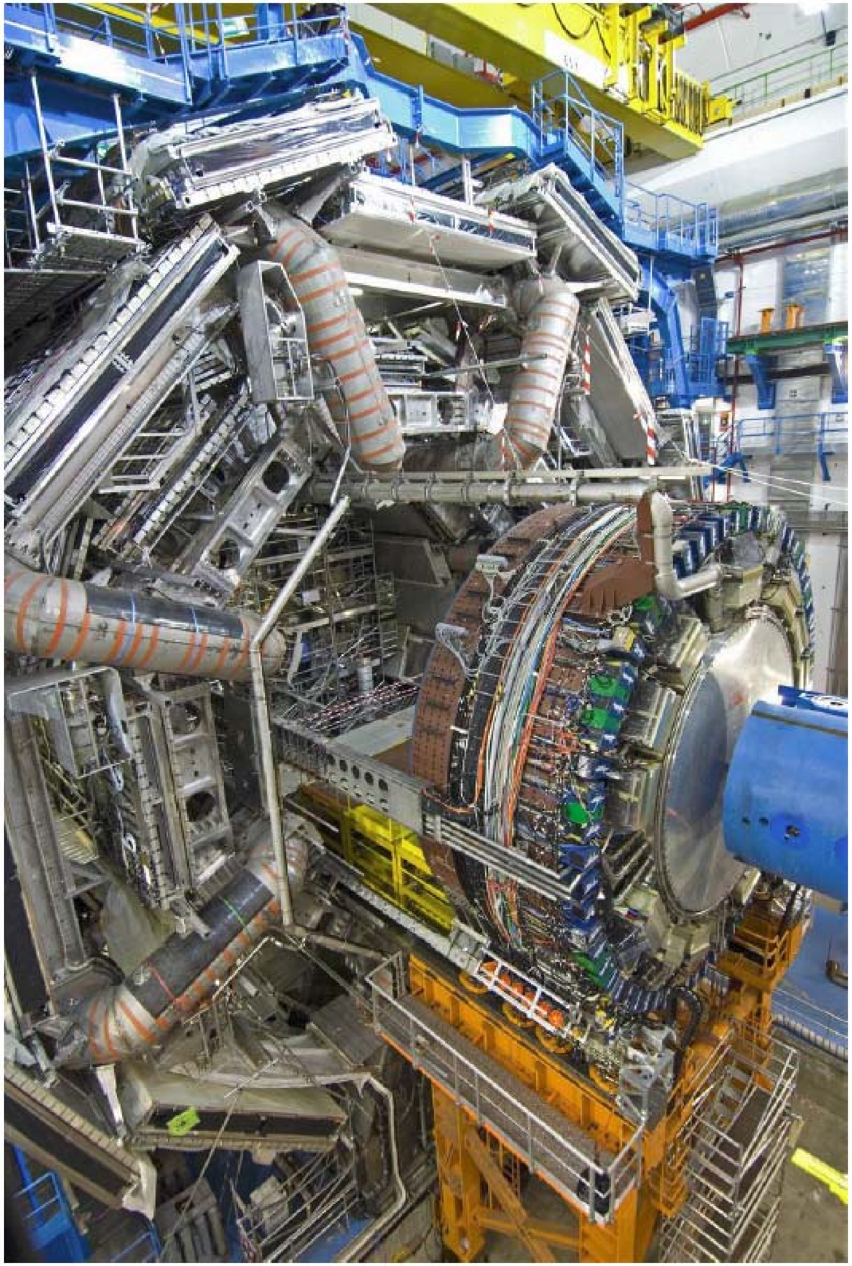
Construction Status of ATLAS Detector Systems



Barrel toroid length	***26 m***
Endcap end-wall chamber span	***46 m***
Overall weight	***7000 Tons***



Integrated LHCC
milestones
LHCC April 2007



LHC Prospects

- Date for first beams/collisions: ⇒ **July 2008**
- Initial physics run starts in summer/fall 2008

  ⇒ collect ~10 fb^{-1} /exp ($2.10^{33} cm^{-2} s^{-1}$) by end of 2009
- Depending on the evolution of the machine…

  ⇒ collect 200-300 fb^{-1} /exp ($3.4\text{-}10.10^{33} cm^{-2} s^{-1}$) in 5-6 years time

Already time to think of upgrading the machine

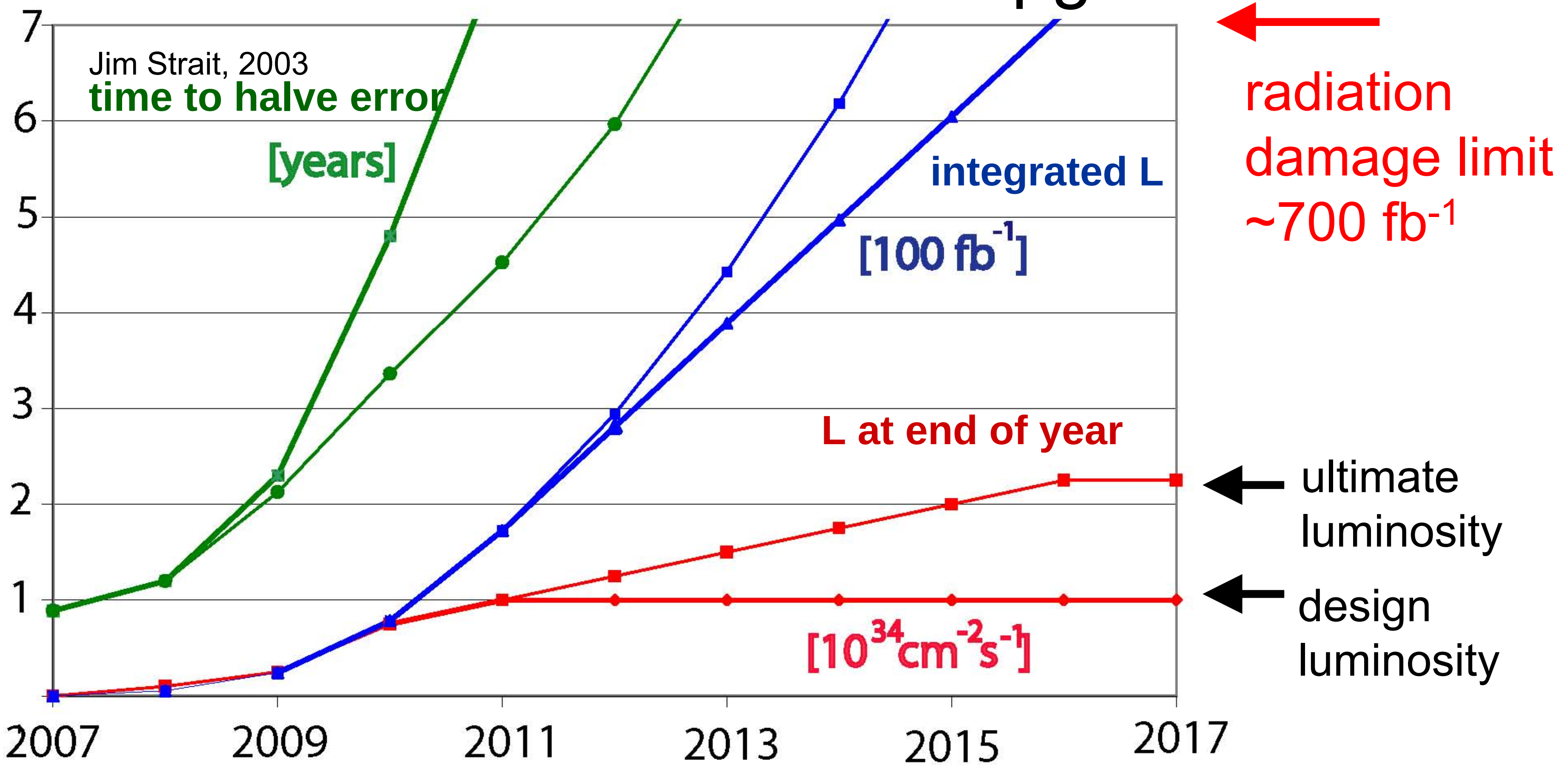
Two options presently discussed/studied

- Higher luminosity ~$10^{35} cm^{-2} s^{-1}$ (SLHC)
  - Needs changes in machine and particularly in the detectors

  ⇒ Start change to SLHC mode some time 2012-2014

  ⇒ Collect ~3000 fb^{-1}/experiment in 3-4 years data taking.
- Higher energy?
  - LHC can reach $\sqrt{s}$ = 15 TeV with present magnets (9T field)
  - $\sqrt{s}$ of 28 (25) TeV needs ~17 (15) T magnets ⇒ R&D + MCHf needed

Time Scale of an LHC upgrade



- Life expectancy of LHC IR quadrupole magnets is estimated to be <10 years due to high radiation doses
- Statistical error halving time exceeds 5 years by 2011-2012 → it is reasonable to plan a *machine luminosity upgrade based on new low-β IR magnets around ~2014-2015*

Machine Upgrade in Stages

- Push LHC performance *without* new hardware
  - luminosity $\rightarrow 2.3\text{x}10^{34}$ cm^{-2}s^{-1}, E_b=7→7.54 TeV
- LHC IR upgrade
  - replace low-β quadrupoles after ~7 years
    peak luminosity $\rightarrow 4.6\text{x}10^{34}$ cm^{-2}s^{-1}
- LHC injector upgrade
  - peak luminosity $\rightarrow 9.2\text{x}10^{34}$ cm^{-2}s^{-1}
- LHC energy upgrade
  - E_b→13 – 21 TeV (15 → 24 T dipole magnets)

Beam-Beam Limit Luminosity Equation

injector upgrade

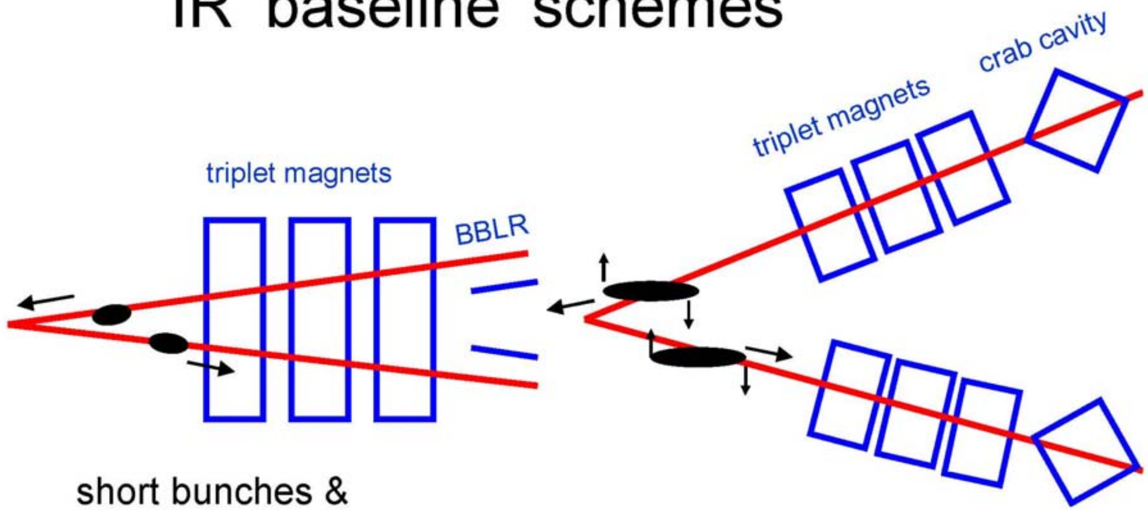
$$L \approx \pi\gamma n_b \frac{(\gamma\varepsilon) f_{rev}}{r_p^2 \beta^*} \Delta Q_{bb}^2 \sqrt{1+\phi^2} F_{profile}$$

LHC + injector changes

IR upgrade

LHC+ injector changes

IR 'baseline' schemes



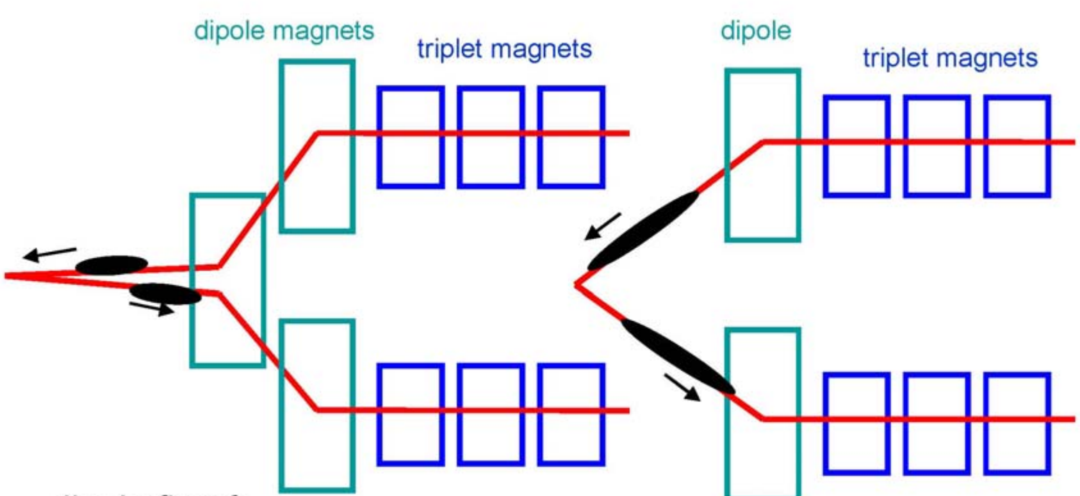
short bunches &
minimum crossing angle &
BBLR

crab cavities &
large crossing angle

"quadrupoles first"

minimum chromaticity

alternative IR schemes → "dipole first"



dipole first &
small crossing angle

dipole first &
large crossing angle &
long bunches or crab cavities

reduced # LR collisions;
collision debris hits first dipole

N. Mokhov et al., PAC2003

"open midplane s.c. dipole"
(studied by US LARP)

Summary of Luminosity Upgrade

Scenarios for $L \sim 10^{35} cm^{-2} s^{-1}$ with acceptable heat load and events/crossing

25-ns: push β^* to limit

- Slim magnets inside detector
- Crab Cavities
- High Gradient, Large Aperture Nb_3Sn Quads

50-ns: Fewer bunches, higher charge

- Realizable with $NbTi$
- Beam-Beam tune shift due to large Piwinski angle?
- Luminosity leveling via bunch length and β^* tuning

Physics Case for the SLHC

The use/need for for the SLHC will obviously depend on how EWSB and/or the new physics will manifest itself

This will only be answered by LHC itself

What will the HEP landscape look like in 2012??

Rough expectation for the SLHC versus LHC

- Improvement of SM/Higgs parameter determination
- Improvement of New Physics parameter determinations, if discovered
- Extension of the discovery reach in the high mass region
- Extension of the sensitivity of rare processes

Indicative Physics Reach

Ellis, Gianotti, ADR
hep-ex/0112004+ updates

Units are TeV (except $W_L W_L$ reach)

☞Ldt correspond to 1 year of running at nominal luminosity for 1 experiment

PROCESS	LHC 14TeV 100 fb^{-1}	SLHC 14TeV 1000 fb^{-1}	SLHC 28TeV 100 fb^{-1}	LinCol 0.8 TeV 500 fb^{-1}	LinCol 5 TeV 100 fb^{-1}
Squarks	2.5	3	4	0.4	2.5
$W_L W_L$	2σ	4σ	4.5σ		
Z'	5	6	8	8†	8†
Extra Dim (δ=2)	9	12	15	5 - 8.5†	30 - 55†
q^*	6.5	7.5	9.5	0.8	5
Λ_{comp}	30	40	40	100	400
TGC (λ_γ)	0.0014	0.0006	0.0008	0.0004	0.00008

† indirect reach
(from precision measurements)

Approximate mass reach machines:

$\sqrt{s}$ = 14 TeV, $L=10^{34}$ (LHC) : up to ≈ 6.5 TeV
$\sqrt{s}$ = 14 TeV, $L=10^{35}$ (SLHC) : up to ≈ 8 TeV
$\sqrt{s}$ = 28 TeV, $L=10^{34}$: up to ≈ 10 TeV

Detectors: General Considerations

	LHC	SLHC
$\sqrt{s}$	14 TeV	14 TeV
L	10^{34}	10^{35}
Bunch spacing Δt	25 ns	25/50 ns
σ_{pp} (inelastic)	~ 80 mb	~ 80 mb
N. interactions/x-ing ($N = L\, \sigma_{pp}\, \Delta t$)	~ 20	~ 280/350
$dN_{ch}/d\eta$ per x-ing	~ 150	~ 2000/2500
$\langle E_T \rangle$ charg. particles	~ 450 MeV	~ 450 MeV
Tracker occupancy	1	10/20
Pile-up noise in calo	1	~9
Dose central region	1	10

Normalised to LHC values.

10^4 Gy/year R=25 cm

In a cone of radius = 0.5 there is E_T ~ 200GeV.
This will make low E_t jet triggering and reconstruction difficult.

Detector Upgrade

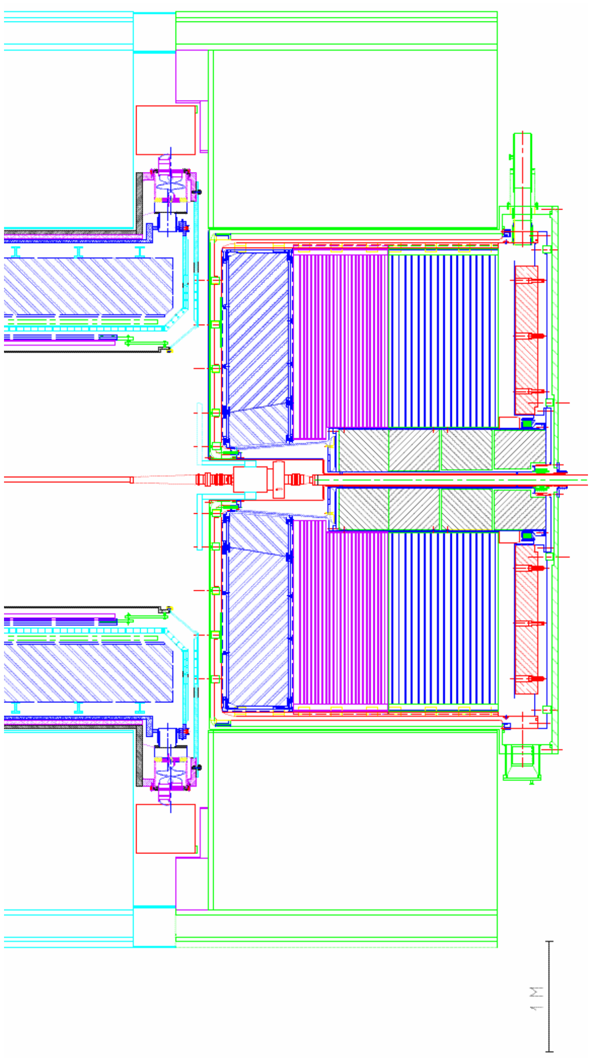
- ATLAS has begun studying what needs to be upgraded for $10^{35} cm^{-2} s^{-1}$ instantaneous luminosity
  - ~10× harsher pileup, radiation environment
  - Also constrained by existing detector: what can be moved/stored where/when
- Major ID overhaul foreseen
  - TRT replaced by Si Strips
  - Pixels move to larger radius
  - New technology for innermost layers
- Calorimeters
  - New FE electronics for HEC
  - New cold or warm FCAL
  - Opening endcap cryostat implies a long installation schedule (~2-3 years)
- Schedule to fit 2016 timescale
  - Aim for upgrade TDR in 2010 to allow adequate procurement/construction
- *Also Trigger, FE in general, etc.. etc.. etc…*

LAr Calorimeters at sLHC - Overview

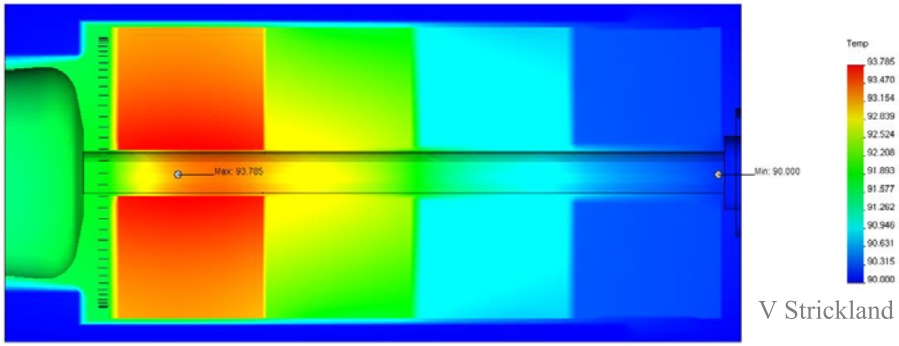
- Critical issues
  - ion build up and heat load

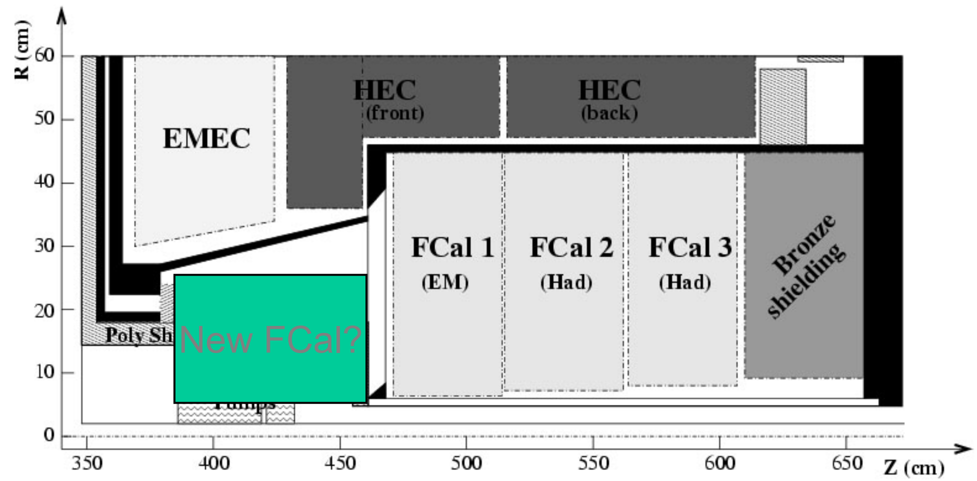
- The HiLum ATLAS Endcap Project

- Radiation hardness:
  - R&D for HEC cold electronics;



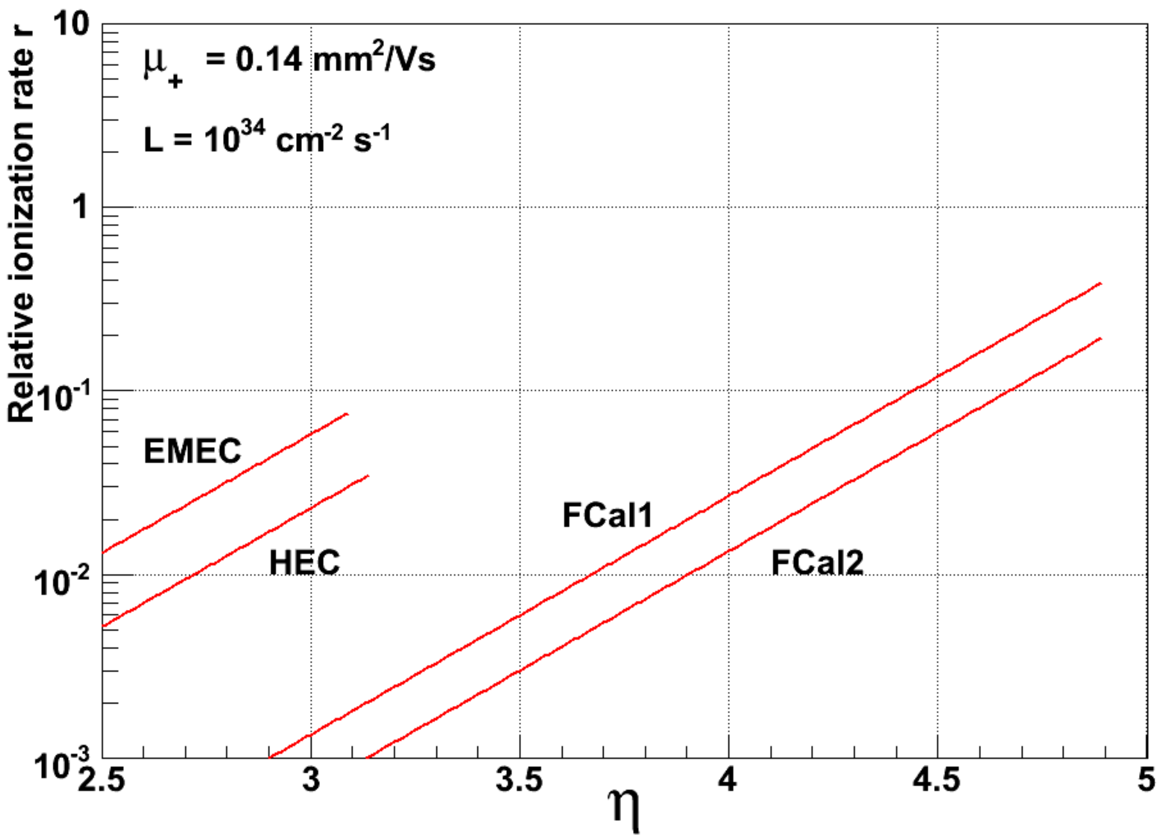
FCal - Heatload





- Simulation of LAr FCAL beam heating
  - Maximum temperature 93.8K – enough to boil LAr
- Uncertainties - convection could make things better or worse; other endcap calorimeters also implicated
- Improve FCAL cooling (open endcap cryostat)
  - *~2-3 year round-trip – big timing challenge*
- New “warm” FCAL plug?

+ve Ion Buildup – Distorts Electric Field



limit r=1

- EMEC and HEC OK
- FCAL: reduce gap from 250 μ to 100 μ

  → **all endcap calorimeters stay in region $r < 1$**

sLHC

HiLum ATLAS Endcap Project

- Goal: establish limitations on the operation of the endcap calorimeters (FCAL, EMEC, HEC) at highest LHC luminosities.
- R&D: 'mini modules' of FCAL, EMEC and HEC type, each in one separate cryostat;
- IHEP Protvino: beam line # 23: from 10^7 up to 10^{12} p/spill; E= 60/70 GeV;
- Arizona, Dresden, JINR Dubna, Kosice, Mainz, LPI Moscow, MPI Munich, BINP Novosibirsk, IHEP Protvino, TRIUMF, Wuppertal.

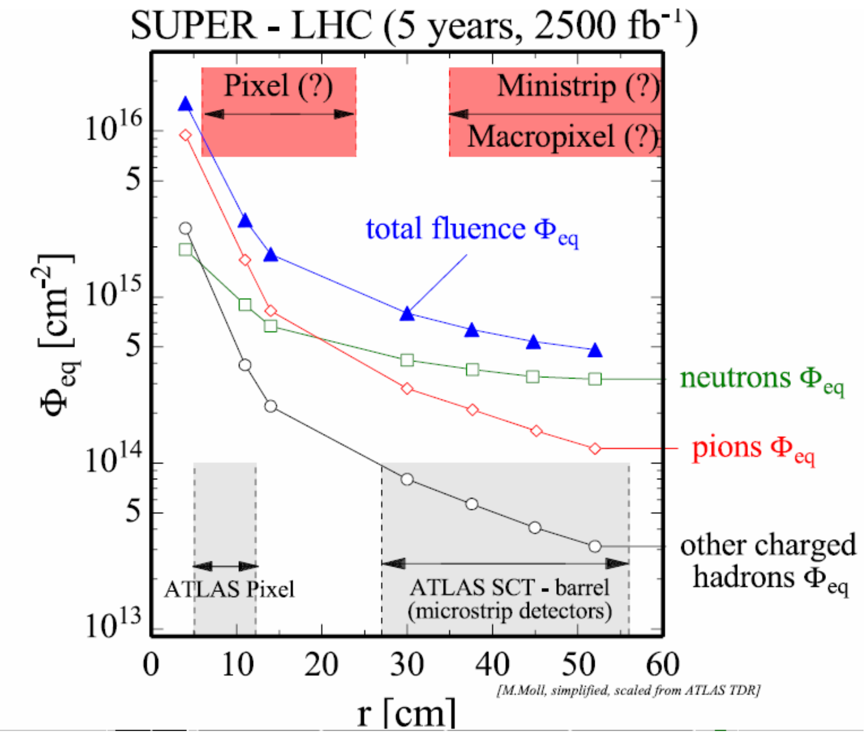
HEC Electronics Upgrade

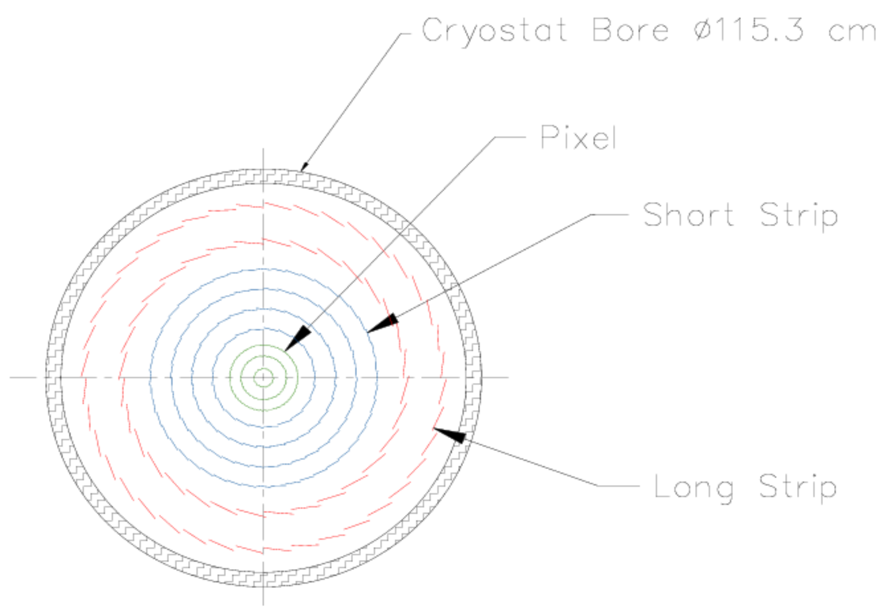
- HEC is equipped with cold electronics based on GaAs ASICs.
  - LHC - expect in 10 years neutron fluence of 0.2×10^{14} n/cm^2
  - Degradation of performance sets in at typically 3×10^{14} n/cm^2
  - Aim for factor of 10 improvement

- Electronics upgrade R&D (Montréal, MPI, Kosice, TRIUMF) four options.
  - 1. Existing chips for sLHC conditions.
  - 2. Re-design ASIC with present GaAs technology
  - 3. Investigate SiGe HBT (Heterojunction Bipolar Transistor)
  - 4. Study warm electronics options: Si (or SiGe) warm preamps

- TRIUMF is contributing to options 2,3,4
  - Schematics development and simulation
  - Validation tests
  - System tests
  - Technical manpower

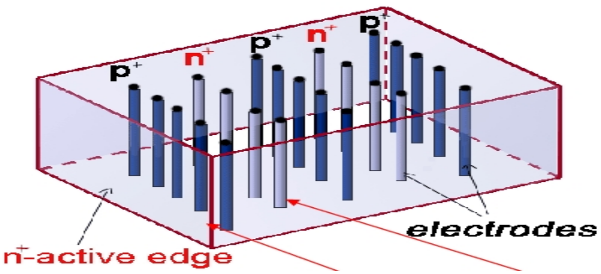
Inner Detector Replacement

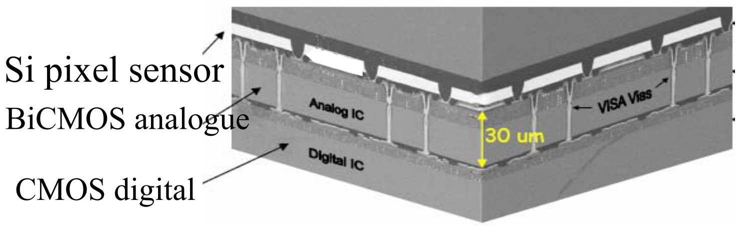


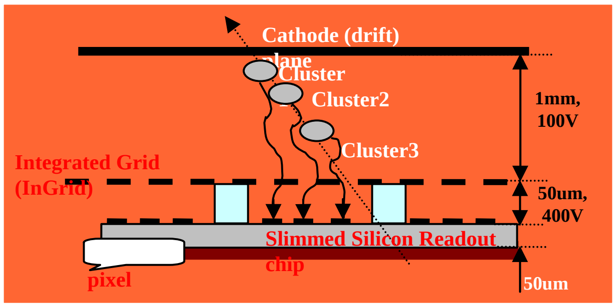


- Order of magnitude increase in Data rates, Occupancy, Irradiation
- No TRT – Si strips
- Pixels moved to larger radius
- New technology for inner layers
- R&D required on sensors, readout, and mechanical engineering

Pixel-layer Technologies







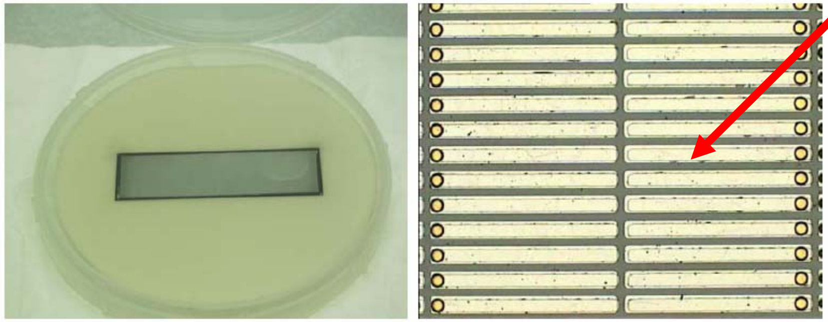


Figure 5: (a) Photograph of the ATLAS pixel diamond mounted in the carrier ready for bump bonding. (b) Zoom view of the pixel pattern after the under-bump metal is deposited.

- Harshest radiation environment (R~4cm)
  - – investigate new technologies
- 3D Si
- Thin silicon + 3D interconnects
- Gas over thin pixel (GOSSIP)
- *Diamond pixels*
- May test in pre-SLHC b-layer replacement (~2012)

Schedule

Strawman & options fixed	Dec 2006
ID R&D, conceptual design	2007-2009
TDR	Feb 2010
ID cooling PRR	April 2010
Silicon sensor PRR	July 2010
ID FE electronics PRR	Oct 2010
b-layer replacement	Ready 2012
Procure parts, component assembly	2010-2012
Start surface assembly	March 2012
Stop data taking	Sep 2014
Remove old detectors, install new	2014-2015
Data	April 2016

Tracker Upgrade work in Canada

Diamond Sensors – Toronto, Carleton, Montréal +…..

- Prove radiation tolerance of pCVD diamond pixel prototypes
- Industrialize bump-bonding
- FE electronics
- Mechanical structure
- Test beam program 2008-2009

Electronics – Carleton, UBC, York, TRIUMF +…..

- FE ASICS – Si FE module controller
  - Initially FPGA, Move to ASIC
- Contribute to system design – develop expertise
- Backend (eg RODs) later in upgrade path
- TRIUMF Technical manpower

Bottom Line

- LHC with Luminosity upgrade will likely be built.
    - Work in Canada needs to start soon
    - Scope for new people and new ideas

MACHINE EXTRAS

MACHINE EXTRAS

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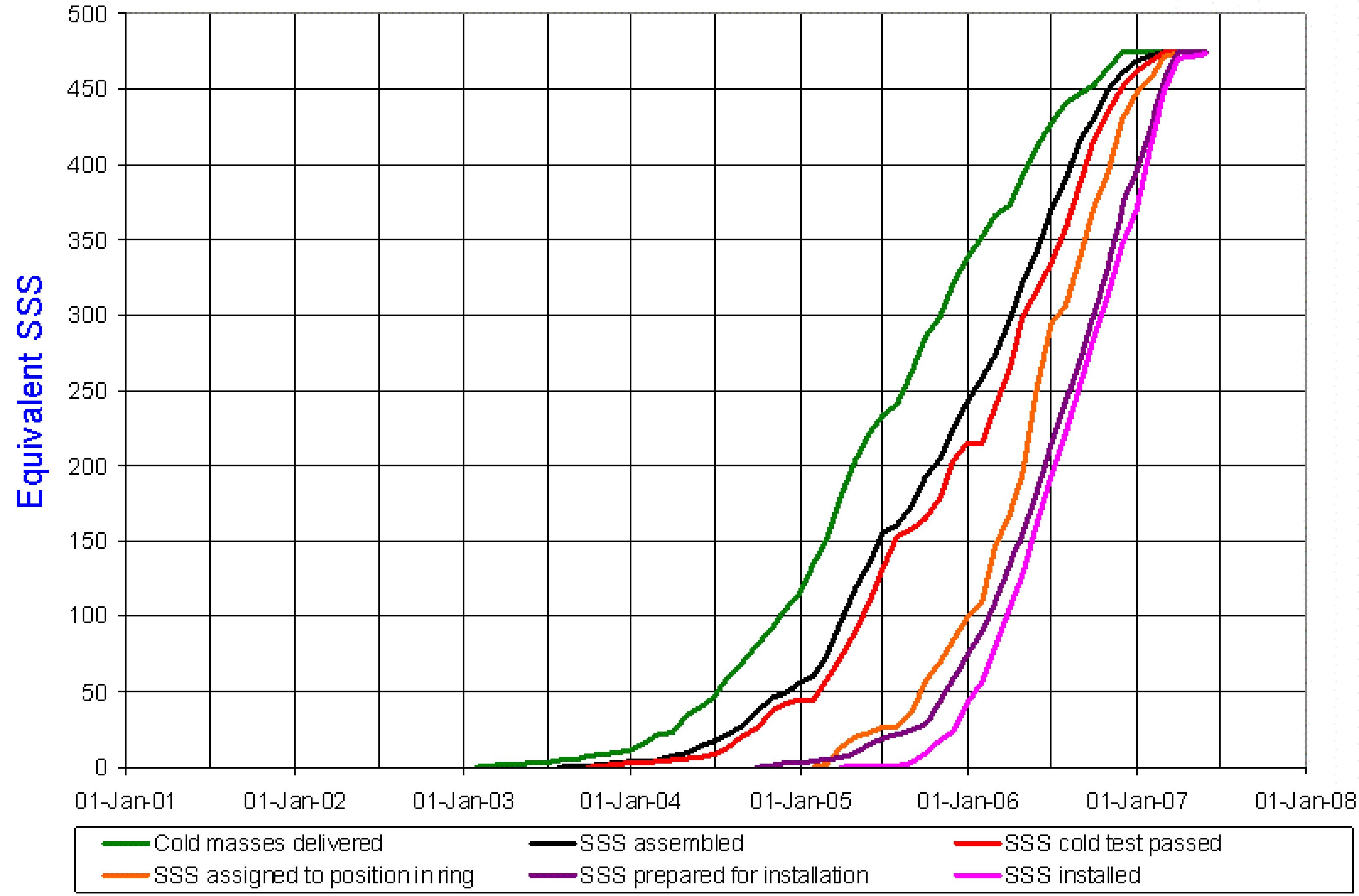
Accelerator Technology Department

Short Straight Section Overview



Data provided by M. Modena AT-MCS, L. Bottura AT-MTM

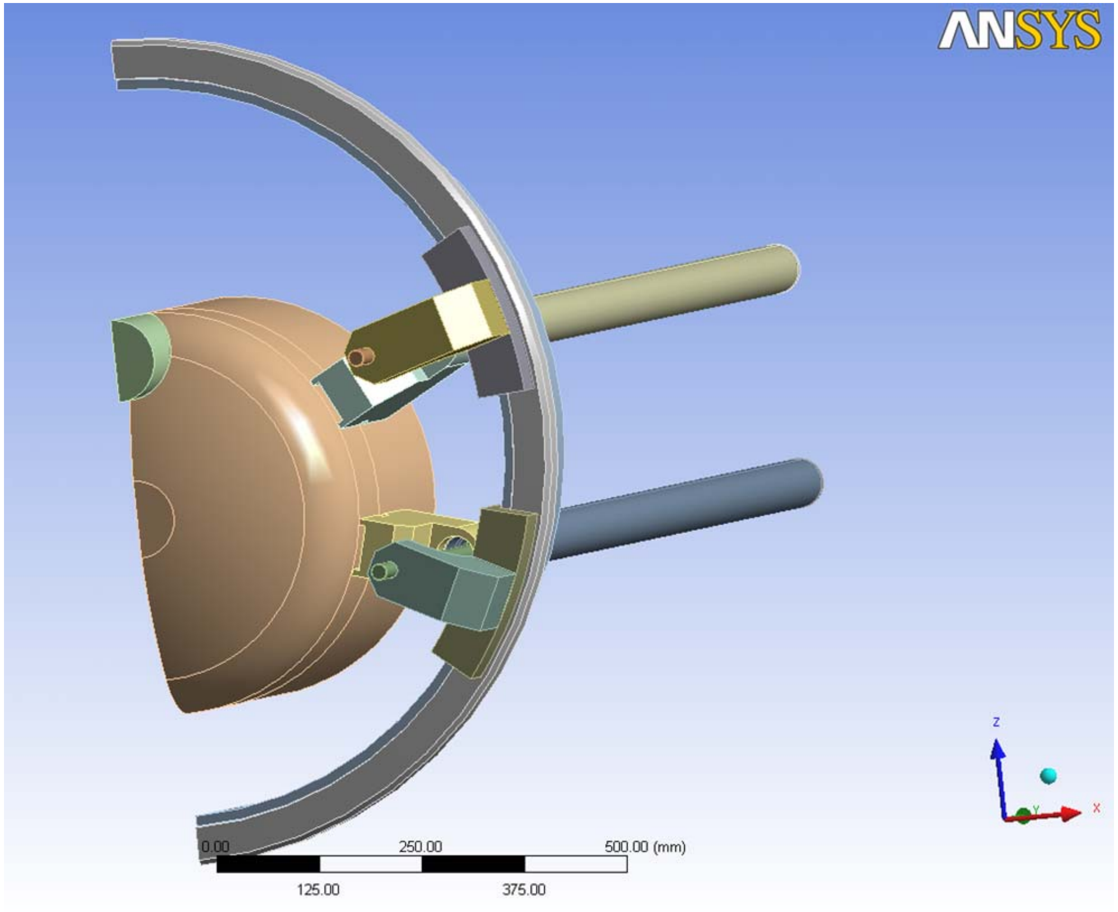
Inner Triplet Problem March 2007

- During the pressure test of the repaired triplet in 5L (27 March 2007), longitudinal fixed points on the “spider” supports of the cold mass broke at 20 bar.
- Loading conditions resulting from such pressure forces not taken into account in the design
- A complete review of the mechanical design of the Inner Triplets was conducted at CERN (24-25 April 2007) - repair solutions based on contraction-compensated compound metallic columns transfering longitudinal pressure forces onto the cryostat outer vessels
- Detailed design and validation of this solution are under way, and an implementation schedule is being established

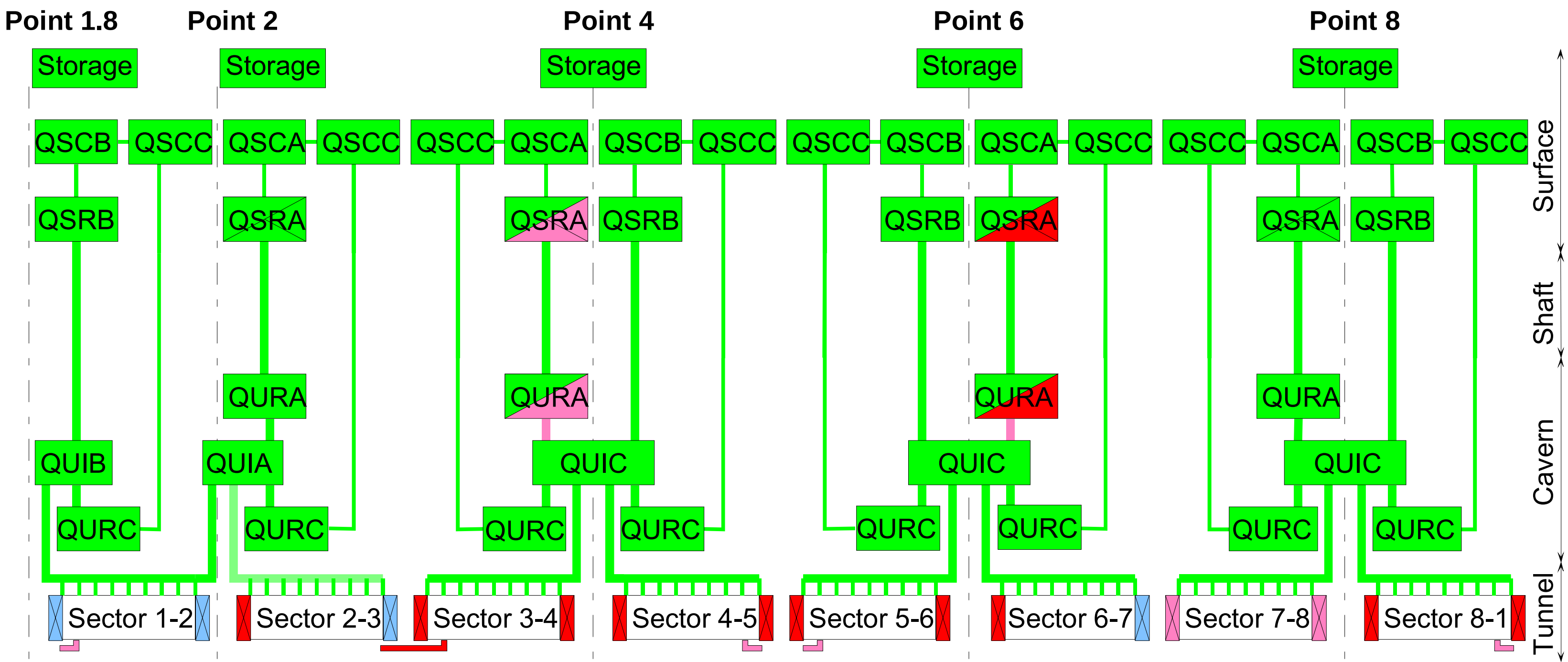
Inner Triplet: Cold Mass

Repair Cartridge

- Affixed at Q1 non-IP end and at Q3 IP end
- Transfer load at all temperatures
- Limits support deflections
- Compound design with Invar rod and aluminium alloy tube
- Attached with brackets to cold mass and cryostat outer vessel



Cryogenic System Overview



Legend

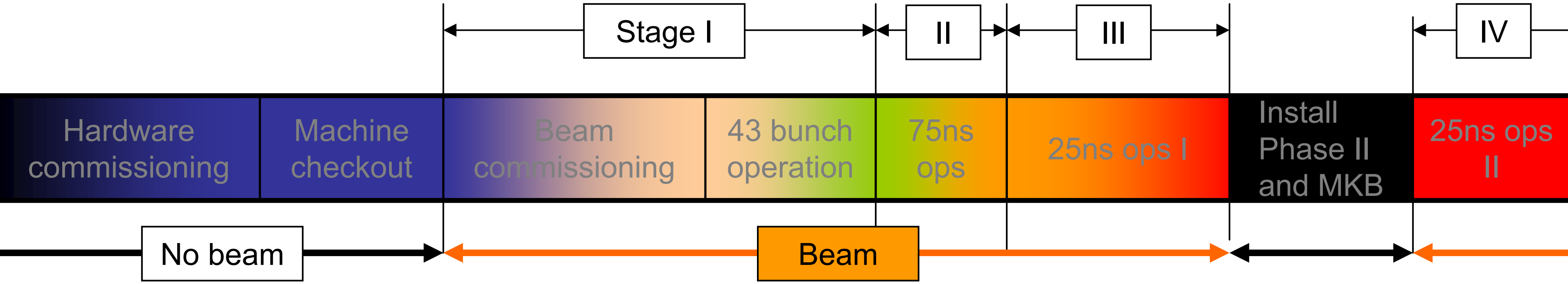
Cryogenic Distribution Line

QSC_(A,B,C): Warm Compressor Station
QSR_(A,B): Surface 4.5 K Refrigerator Cold Box
QURA: Underground 4.5 K Refrigerator Cold Box
QURC: 1.8 K Refrigeration Unit Cold Box
QUI_(A,B,C): Cryogenic Interconnection Box

Electrical Feed Box
Superconducting Link

Commisionned & accepted
Delivered / Under installation
Ordered (Contract placed)
Under commissioning
Under fabrication
Under definition

Staged Commissioning Plan for Protons (R. Bailey)



Pilot physics run

- First collisions
- 43 bunches, no crossing angle, no squeeze, moderate intensities
- Push performance (156 bunches)
- *Performance limit 10^{32} cm^{-2} s^{-1} (event pileup)*

75ns operation

- Establish multi-bunch operation, moderate intensities
- Relaxed machine parameters (squeeze and crossing angle
- Push squeeze and crossing angle
- *Performance limit 10^{33} cm^{-2} s^{-1} (event pileup)*

25ns operation I

- Nominal crossing angle
- Push squeeze
- Increase intensity to 50% nominal
- *Performance limit 2 10^{33} cm^{-2} s^{-1}*

25ns operation II

- Push towards nominal performance

Machine upgrade

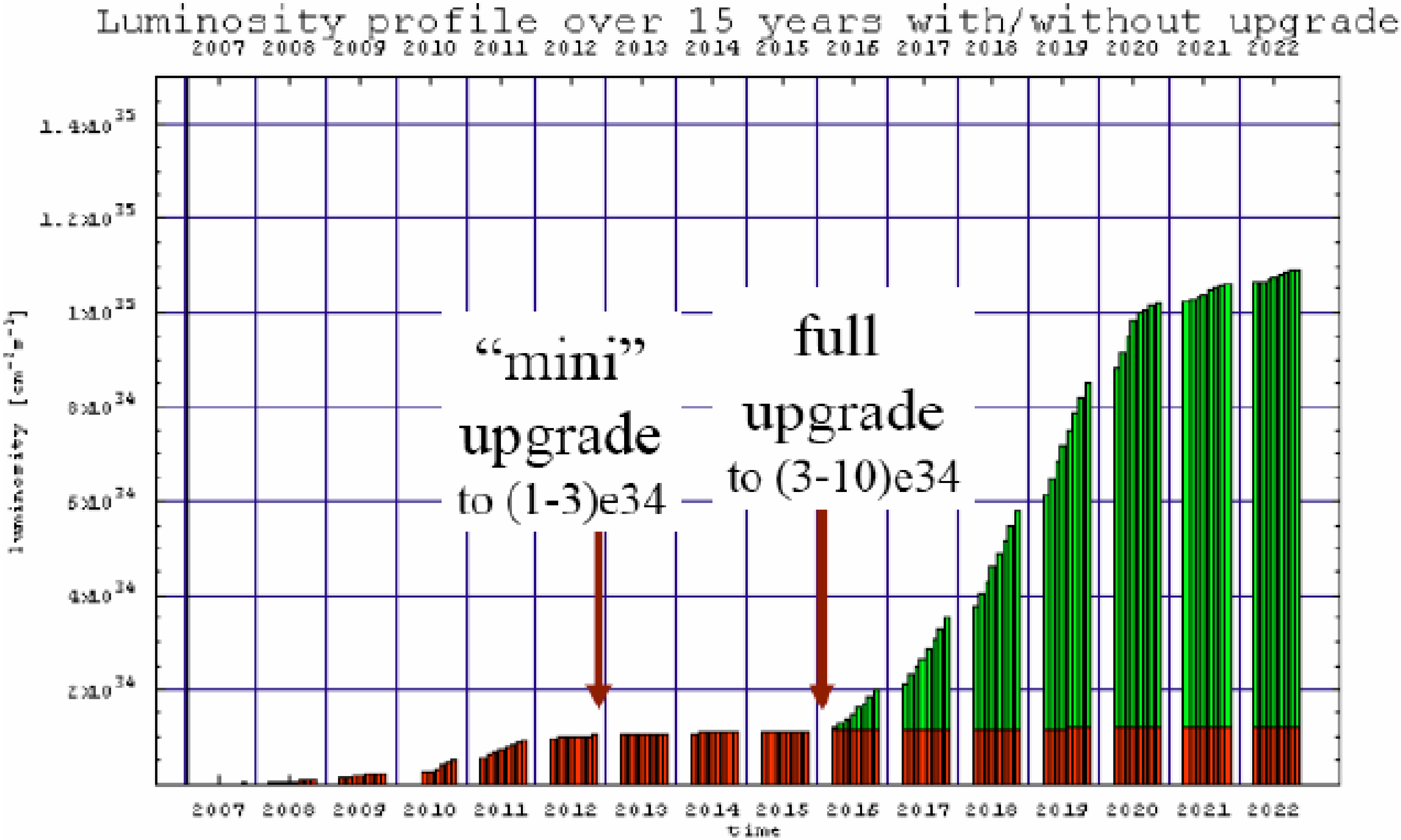
parameter	nom.	ult.	upgrades	
no. of bunches n_b	2808	2808	2808	1
rms bunch length σ_z [cm]	7.6	7.6	7.6, 4.2	7500
rms energy spread σ_δ [10^{-4}]	1.1	1.1	1.1, 3.7	5.8
beta at IP [m] β^*	0.5	0.5	0.25	0.25
crossing angle θ [μrad]	300	315	485	1000
beam current I_b [A]	0.56	0.86	1.3, 1.3	1.0
luminosity L [10^{34} cm^{-2}s^{-1}]	1	2.3	7.3, 9.7	9.0
σ_δ IBS growth time τ_{IBS} [h]	134	86	56, 674	1712

Latest parameter set:
F. Ruggiero et al.
PAC2003 report
May 2003

A luminosity of 10^{35}cm^{-2} s^{-1} seems possible

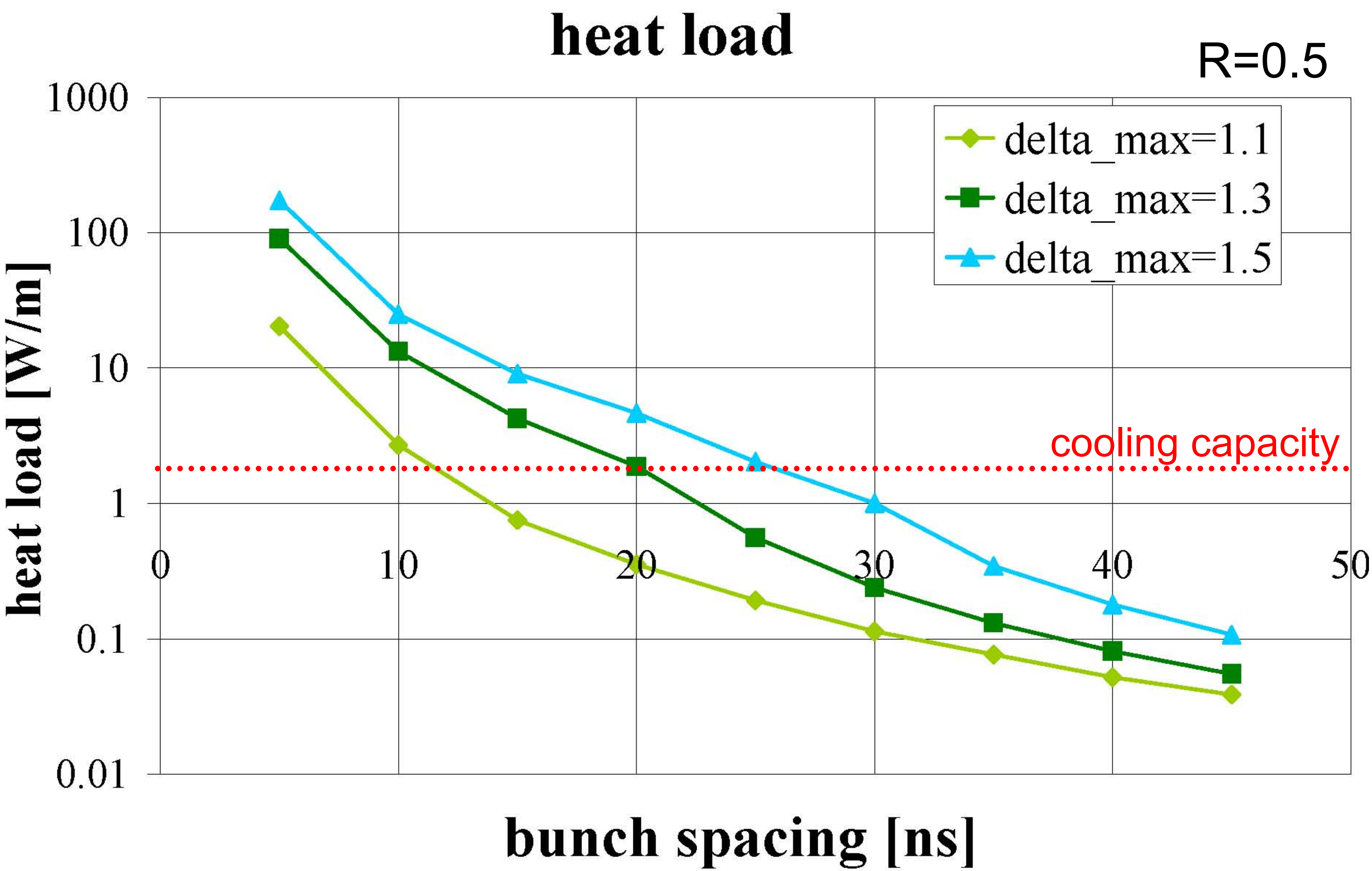
(*) Superbunch: 1 bunch of 75 m (rms) in each ring
Good for electron cloud effects/bad for experiments: 50000 events/25 ns slice

LHC luminosity upgrade: the LARP perspective



Courtesy of V. Shiltsev - FNAL

arc heat load vs. spacing, N_b=1.15x10[11], 'best' model

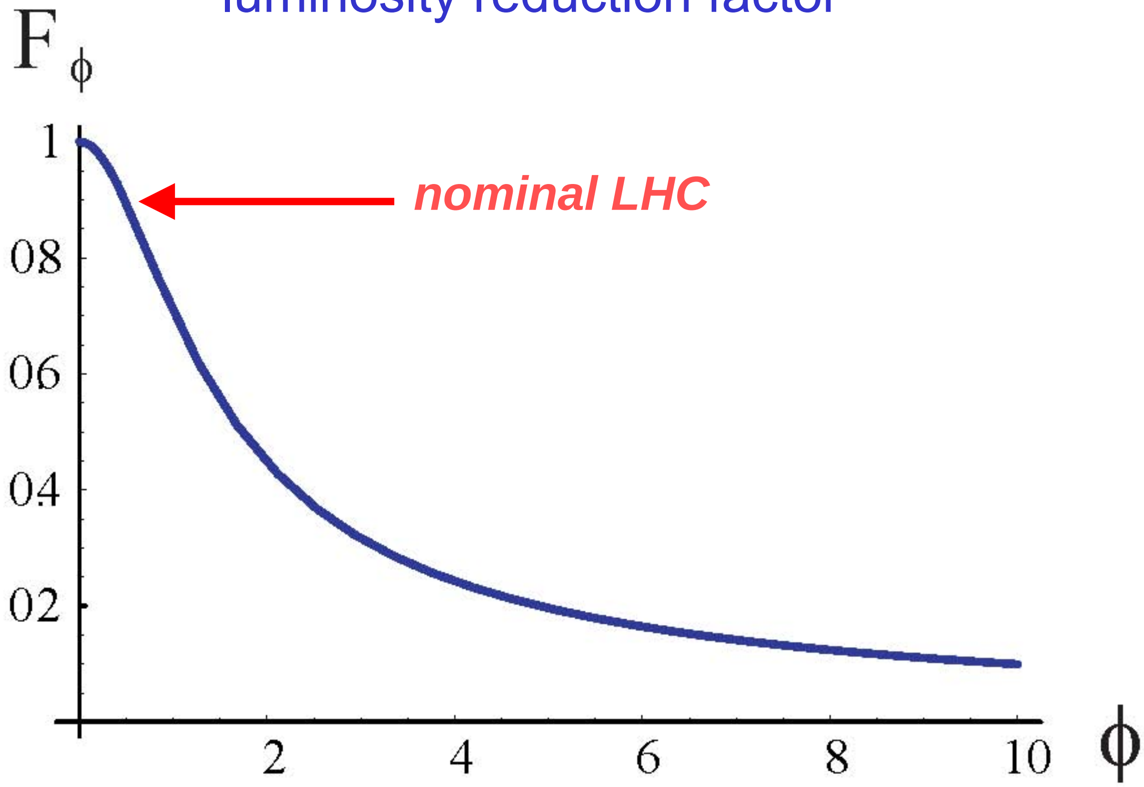


Nominal Crossing Angle "at the edge"

$$F_\phi = \frac{1}{\sqrt{1+\phi^2}}; \quad \phi \equiv \frac{\theta_c \sigma_z}{2\sigma_x}$$

Piwinski angle

luminosity reduction factor

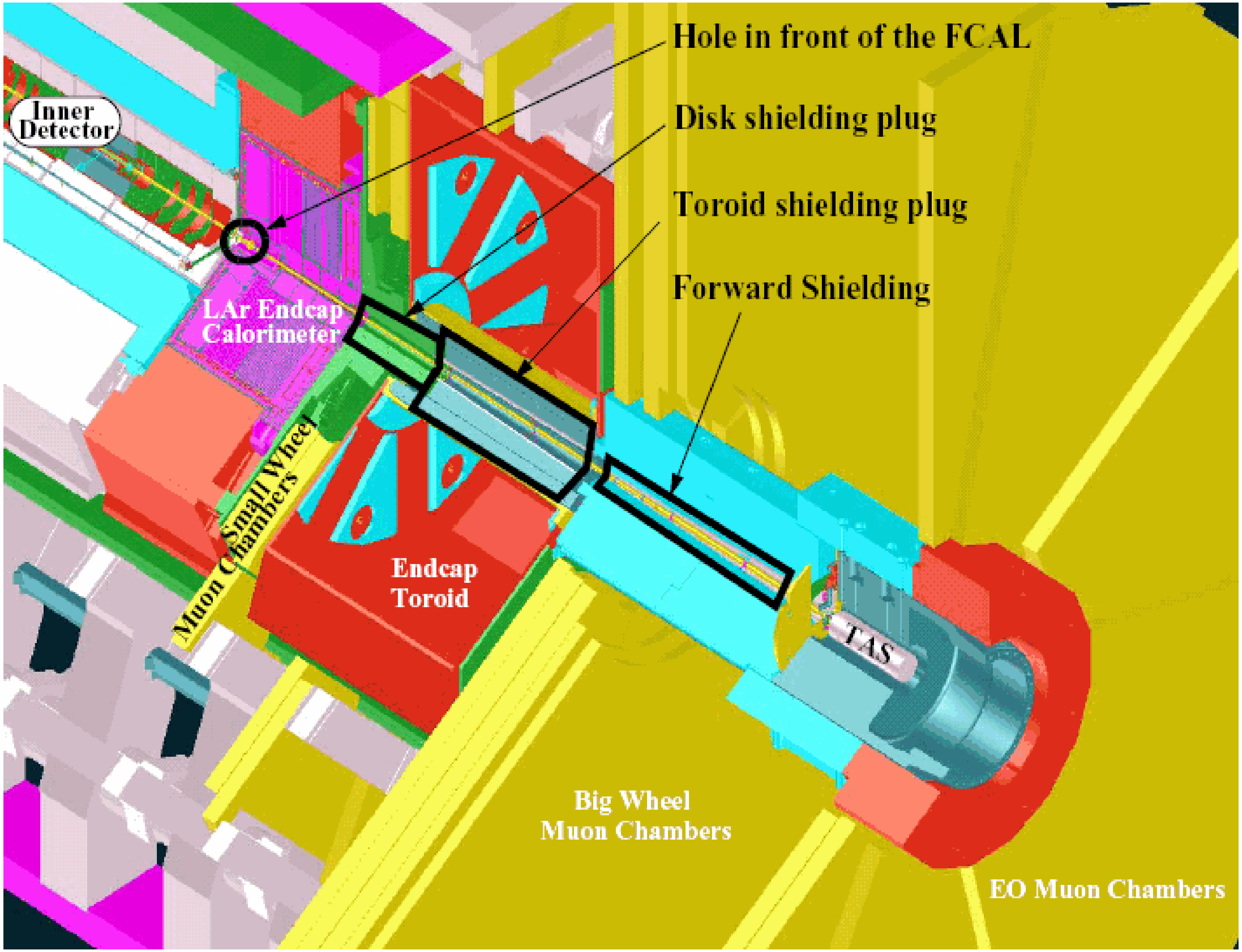


Basic Ingredients

- Bunch spacing or bunch frequency
- Number of protons/bunch
- Bunch length, bunch profile
- Emittance
- Crossing angle
- ß* i.e ß at the IP
- L* i.e distance between IP and the starting point of the inner triplet
- Aperture,gradient and length of the inner triplet (also technology NbTi/NbSn)
- IP layout i.e dipole or quadrupole first
- Early separation schemes - D0 inside ATLAS
- Crab cavities
- Slim quadrupoles (Q0) to modify the behaviour of ß inside the experiment
- Wire compensation for long range beam-beam compensation

Some of these ingredients only works in combination with others and some are independent

Slim magnets inside ATLAS



LUMI'06 parameters

parameter	symbol	ultimate	25 ns, smaller β*	25 ns, large ε	50 ns, long
transverse emittance	ε [μm]	3.75	3.75	7.5	3.75
protons per bunch	N_b [10^{11}]	1.7	1.7	3.4	4.9
bunch spacing	Δt [ns]	25	25		50
beam current	I [A]	0.86	0.86	1.72	1.22
longitudinal profile		Gauss	Gauss	Gauss	Flat
rms bunch length	σ_z [cm]	7.55	7.55	3.78	14.4
beta* at IP1&5	β* [m]	0.5	0.08	0.25	0.25
full crossing angle	θ_c [μrad]	315	100	539	381
Piwinski parameter	$\theta_c\sigma_z/(2\sigma_x^*)$	0.75	0.60	0.64	2.5
peak luminosity	L [10^{34} cm^{-2}s^{-1}]	2.3	15.5	9.7	8.9
events per crossing		44	296		340
initial lumi lifetime	τ_L [h]	14	2.1	6.8	5.3
effective luminosity ($T_{turnaround}$=10 h)	L_{eff}[10^{34} cm^{-2}s^{-1}]	0.91	2.4	2.7	2.3
	$T_{run,opt}$ [h]	17.0	6.5	12.0	10.3
effective luminosity ($T_{turnaround}$=5 h)	L_{eff}[10^{34} cm^{-2}s^{-1}]	1.15	3.6	3.6	3.1
	$T_{run,opt}$ [h]	12.0	4.6	8.5	7.3
e-c heat SEY=1.4(1.3)	P [W/m]	1.04 (0.59)	1.04 (0.59)	2.56 (2.1)	0.36 (0.1)
SR heat load 4.6-20 K	P_{SR} [W/m]	0.25	0.25	0.5	0.36
image current heat	P_{IC} [W/m]	0.33	0.33	3.74	0.78
gas-s. 100 h (10 h) τ_b	P_{gas} [W/m]	0.06 (0.56)	0.06 (0.56)	0.11 (1.13)	0.09 (0.9)
comment			D0 + crab	wire comp.	wire comp.

new upgrade parameters

Hardware needed for these two scenarios

- 25 ns small ß (8 cm)
  - New triplet with bigger aperture (L* =23m)
  - Small angle crab cavity (~100 m from IP)
  - D0 needed
  - If NbTi technology Qo is needed
  - If Nb_3Sn technology no Qo needed
- 50 ns long bunch
  - New triplet with bigger aperture (L*=23 m)
  - No D0 needed
  - Both NbTi and Nb_3Sn possible without need for Qo
  - Wire compensation needed (~100 m from IP)

Relevant parameters for two scenarios

	25 ns small ß	50 ns long bunc
– Bunch spacing:	25 ns	50 ns
– Rms bunch length:	7.55 cm	14.4 cm
– Long. Profile:	Gauss	Flat
– Luminous region:	2.5 cm	3.5 cm
– Peak lumi:	15.5 10^{34}	8.9 10^{34}
– Events crossing:	296	340
– Lumi. Life time:	2.1 h	5.3 h
– Effective lumi : • (10 h turn around)	2.4 10^{34}	2.3 10^{34}
– Effective lumi: (5 h turn around)	3.6 10^{34}	3.1 10^{34}

zoom on decay time & integrated luminosity for various options

parameter	symbol	nominal	ultimate	12.5 ns	25 ns, smaller β*	50 ns, long
max. # events / crossing		19	44	88	296	340
peak luminosity	L [1e34 cm-2s-1]	1	2.3	9.2	14.4	8.9
effective beam decay time	τ_{eff} [h]	45	29	14.4	4.6	10.7
effective luminosity ($T_{turnaround}$=10 h)	L_{eff} [10^{34} $cm^{-2}s^{-1}$]	0.46	0.91	2.7	2.4	2.3
	$T_{run,opt}$ [h]	21.2	17.0	12.0	6.5	10.3
effective luminosity ($T_{turnaround}$=5 h)	L_{eff} [10^{34} $cm^{-2}s^{-1}$]	0.56	1.15	3.6	3.6	3.1
	$T_{run,opt}$ [h]	15.0	12.0	8.5	4.6	7.3

Average events/bc 150 208

Heat load

zoom on heat load

parameter	symbol	nominal	ultimate	12.5 ns	25 ns, smaller β*	50 ns, long
SR heat load 4.6-20 K	P_{SR} [W/m]	0.17	0.25	0.5	0.25	0.36
image current heat	P_{IC} [W/m]	0.15	0.33	1.87	0.33	0.78
total BS heat load w/o e-cloud	$P_{SR} + P_{IC}$ [W/m]	0.32	0.58	2.37	0.58	1.14
local cooling limit*	P_{cool} [W/m]	2.4	2.4	2.4	2.4	2.4
cooling remaining for e-cloud	$P_{cool, rest}$ [W/m]	2.08	1.82	0.03	1.82	1.26
simulated e-c heat for SEY=1.4 (1.3)	P [W/m]	1.07 (0.44)	1.04 (0.6)	13.34 (7.85)	1.04 (0.59)	0.36 (0.1)

* L. Tavian, LUMI'06

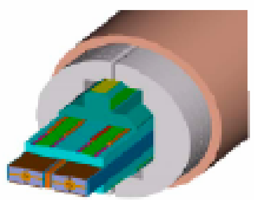
Not feasible (12.5 ns)

OK (25 ns, smaller β*; 50 ns, long)

LHC energy doubler 14*14 TeV

- dipole field B_{nom} = 16.8 T, B_{design} = 18.5-19.3 T (10-15% margin)
  - superconductor - Nb_3Sn
  - 10-13 T field demonstrated in several 1-m long Nb3Sn dipole models
  - DLHC magnet parameters well above the demonstrated Nb3Sn magnet technology
- R&D and construction time and cost estimates
  - 10+ years for magnet technology development and demonstration
  - Magnet production by industry ~ 8-10 years
  - High cost for R&D and construction (cost of dipoles > 3GCHF ?)

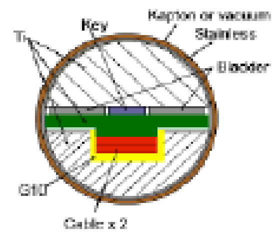
LHC Energy Upgrade

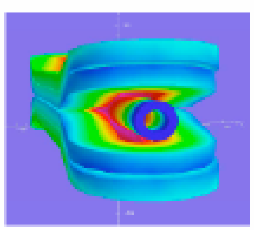


Design Features & Applications

- Target field 15 Tesla
- Clear bore 36 mm
- Simple coil configuration
- Designed for high field quality
- Suitable for HF cable testing
- Compatible with HTS inserts

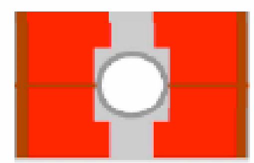
High-field cable testing





4.5 K Short Sample Parameters

Parameter	Unit	HD1	HD2
Clear bore	mm	8	36
Coil field	Tesla	16.1	15.8
Bore field	Tesla	16.7	15.0
Max current	kA	11.4	17.3
Stored Energy	MJ/m	0.66	0.84
F_x (quadrant, 1ap)	MN/m	4.7	5.6
F_y (quadrant, 1ap)	MN/m	-1.5	-2.6
Ave. stress (h)	MPa	150	150



2-layer winding without spacers in body or ends

LHC energy tripler 21*21 TeV

- dipole field B_{nom} = 25 T, B_{design} = 28-29 T (10-15% margin)
  - superconductor - HTS-BSCCO (low demand) or Nb_3Sn
  - Magnet technology to be fully demonstrated
  - DLHC magnet parameters well above the demonstrated Nb3Sn magnet technology
- Large aperture dipole to accommodate an efficient beam screen

- R&D and construction time and cost/risk estimates
  - 20++ years for magnet technology development and demonstration
  - Extremely high R&D and construction cost and risk
    - SC cable to be developed,
    - Magnetic coil stress requires innovative dipole cross section
  - Magnet production by industry (?) ?? years

LHC Energy Doubler 14*14 TeV

Dipoles: B_{nom}=16.8T, B_{design}=19T

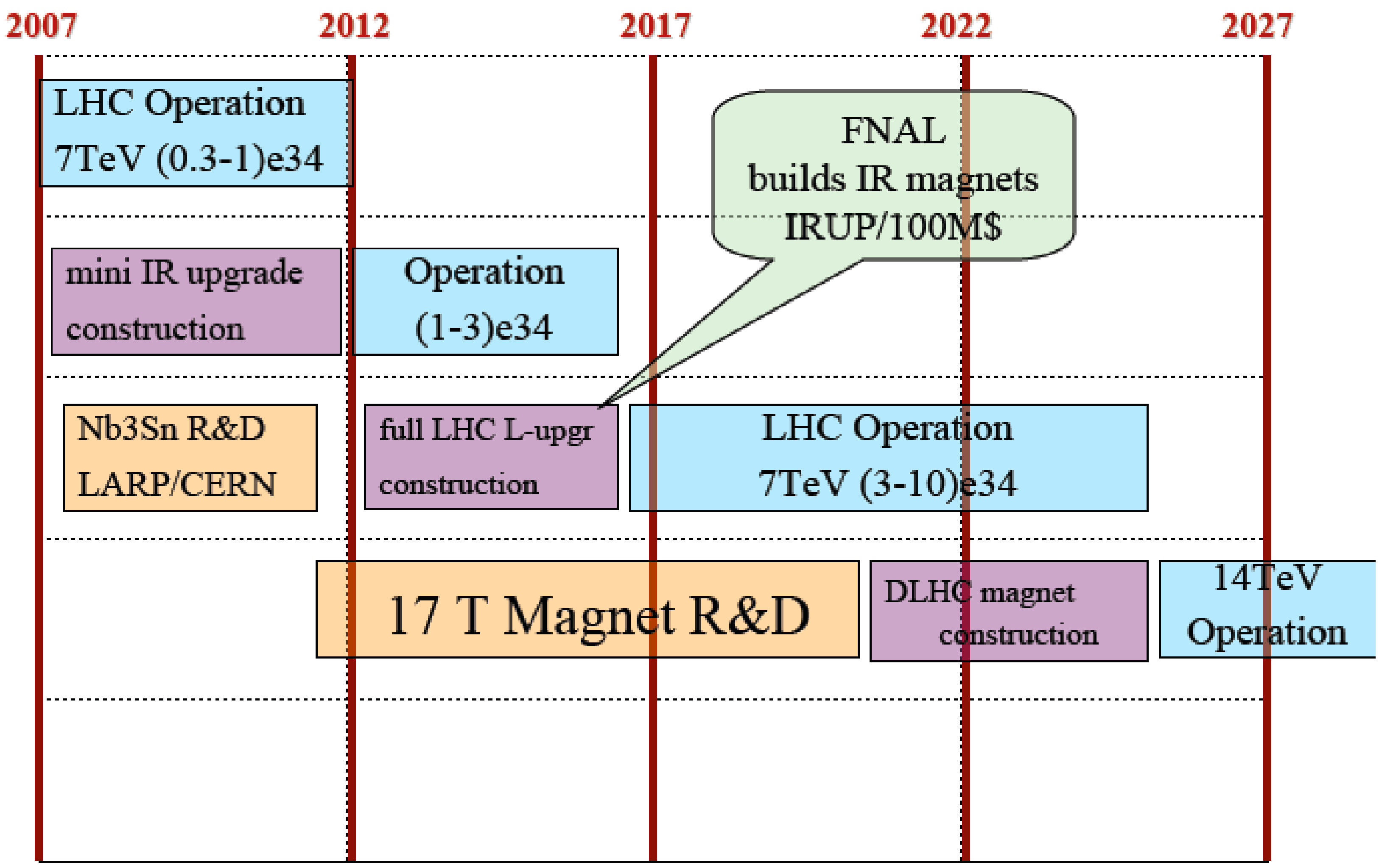
- Superconductor Nb_3Sn
- 16T demonstrated at 4K
- 10 years for R&D, 10 years production
- 3G$

LHC Energy Tripler 21*21 TeV

Dipoles: B_{nom}=25T, B_{design}=29T

- Superconductor HTS-BSCCO or Nb_3Sn
- Well above demonstrated Nb_3Sn
- 20++ years for R&D, ? years production
- ?G$

LHC, sLHC, DLHC perspective

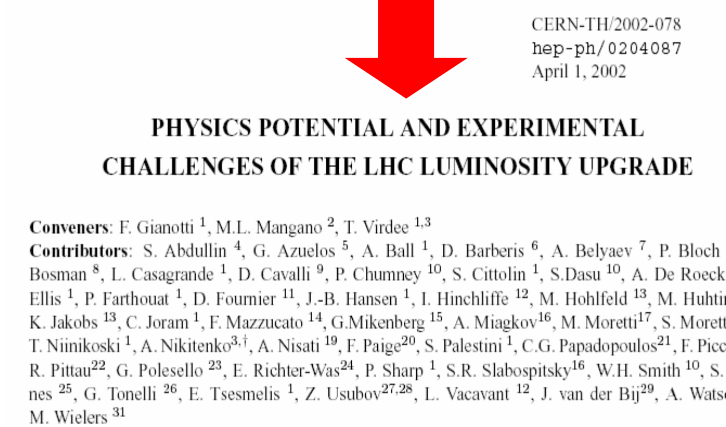


SLHC Physics Extras

Extending the Physics Potential of LHC

- **Electroweak Physics**
  - production of multiple gauge bosons ($n_V \geq 3$)
  - triple and quartic gauge boson couplings
  - top quarks/rare decays
- **Higgs physics**
  - rare decay modes
  - Higgs couplings to fermions and bosons
  - Higgs self-couplings
  - Heavy Higgs bosons of the MSSM
- **Supersymmetry**
- **Extra Dimensions**
  - Direct graviton production in ADD models
  - Resonance production in Randall-Sundrum models TeV^{-1} scale models
  - Black Hole production
- **Quark substructure**
- **Strongly-coupled vector boson system**
  - $W_L Z_L$ g $W_L Z_L$, $Z_L Z_L$ scalar resonance, $W^+_L W^+_L$
- **New Gauge Bosons**

Examples studied in some detail


CERN-TH/2002-078
hep-ph/0204087
April 1, 2002

PHYSICS POTENTIAL AND EXPERIMENTAL CHALLENGES OF THE LHC LUMINOSITY UPGRADE

Conveners: F. Gianotti [1], M.L. Mangano [2], T. Virdee [1,3]
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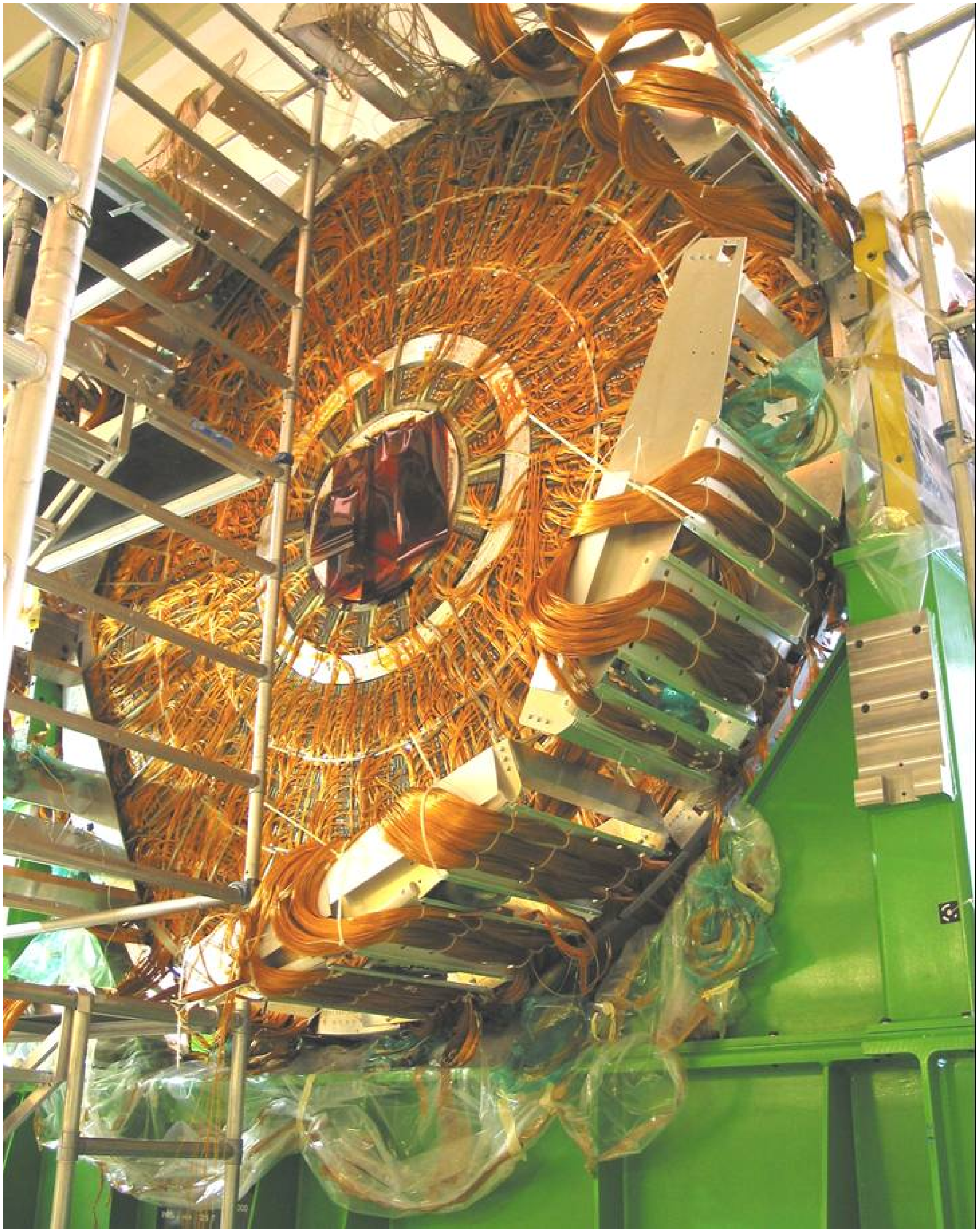
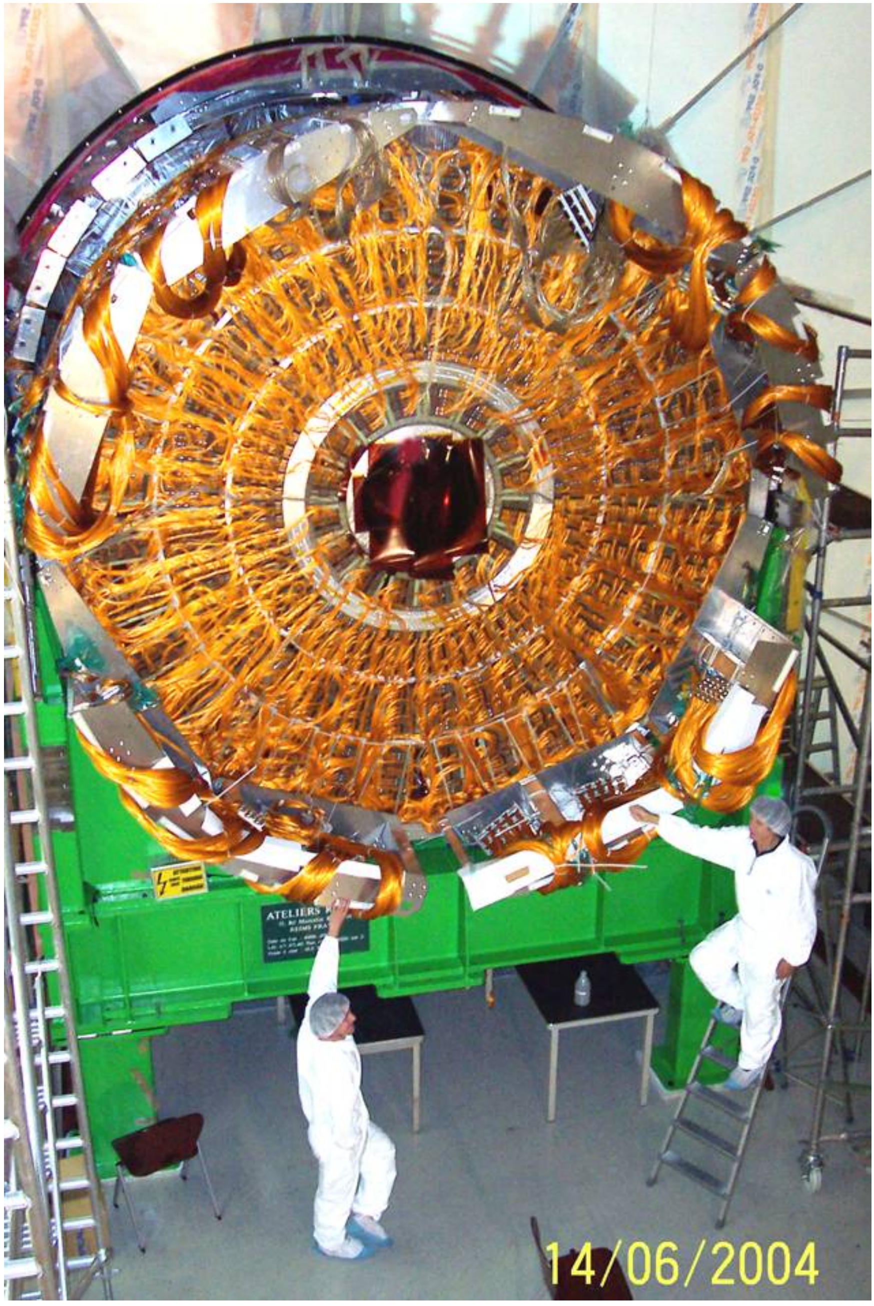
M. Wielers [31]

Include pile up, detector

Preliminary…

EM EndCap A wheel on the insertion stand, May - June 2004





LAr Forward Calorimeters

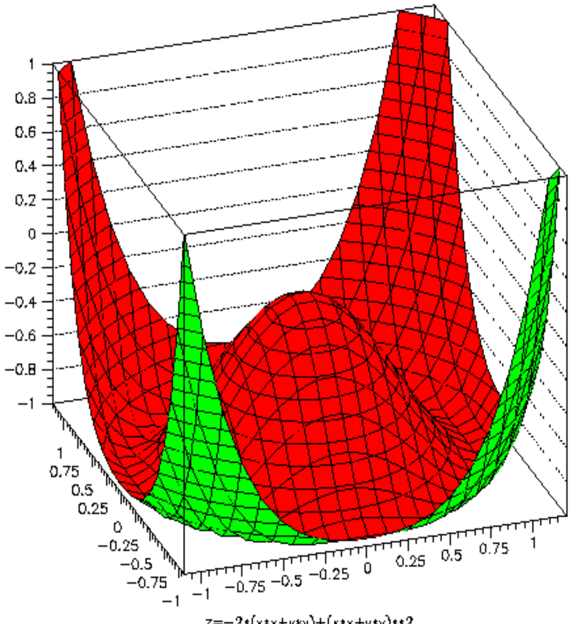
- C end in Cryostat
- A end assembled into support tube

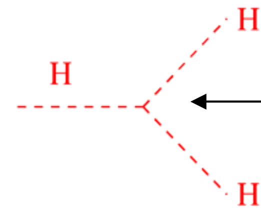
- FCAL C assembly into tube – Fall 2003

Higgs Self Coupling Measurements

Once the Higgs particle is found, try to reconstruct the Higgs potential

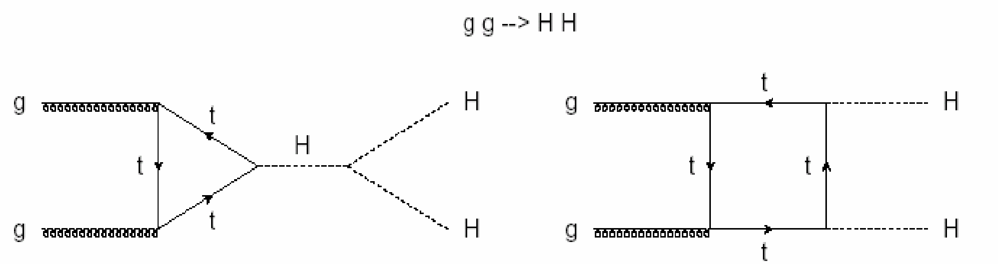
$$V(\Phi) = -\lambda v^2 (\Phi^\dagger \Phi) + \lambda (\Phi^\dagger \Phi)^2$$

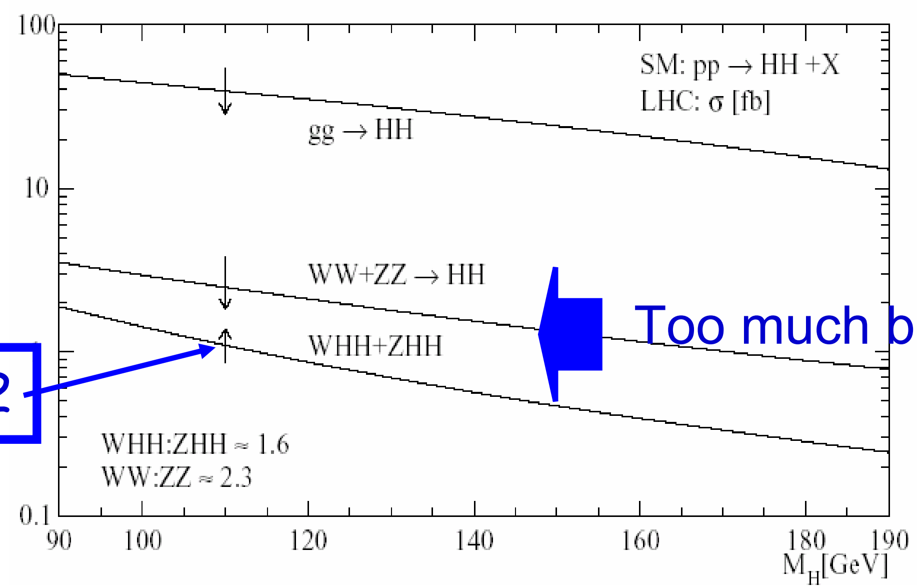




$\sim \lambda v$

$m_H^2 = 2\,\lambda\, v^2$





Djouadi et al.

$\lambda_{SM}/2 < \lambda < 3\lambda_{SM}/2$

Too much backgr.

Not possible at the LHC

Higgs Self Couplings

LHC : σ (pp $\rightarrow$ HH) < 40 fb m_H > 110 GeV
+ small BR for clean final states $\rightarrow$ **no sensitivity**

SLHC : HH $\rightarrow W^+ W^- W^+ W^- \rightarrow \ell^{\pm} \nu jj \ \ \ell^{\pm} \nu jj$

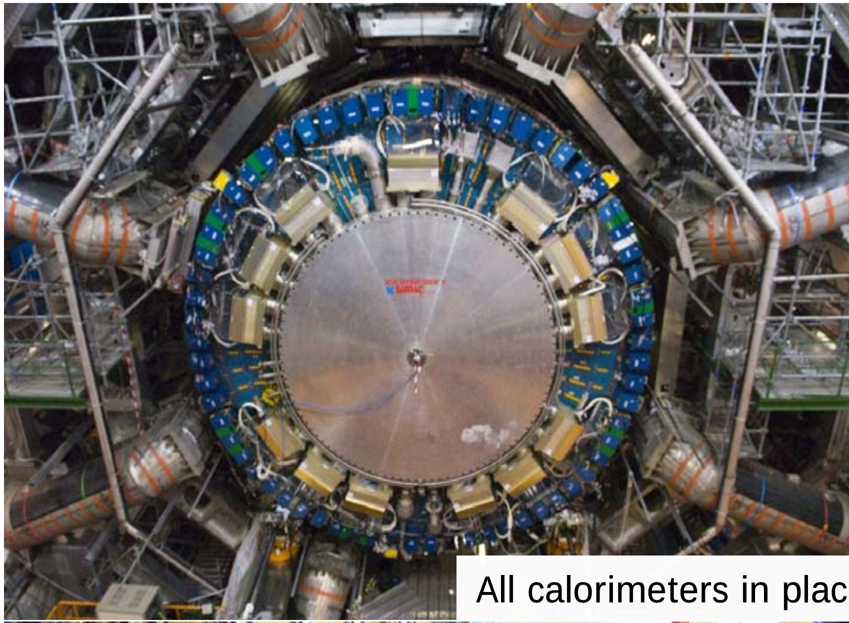
studied (<u>very preliminary</u>)

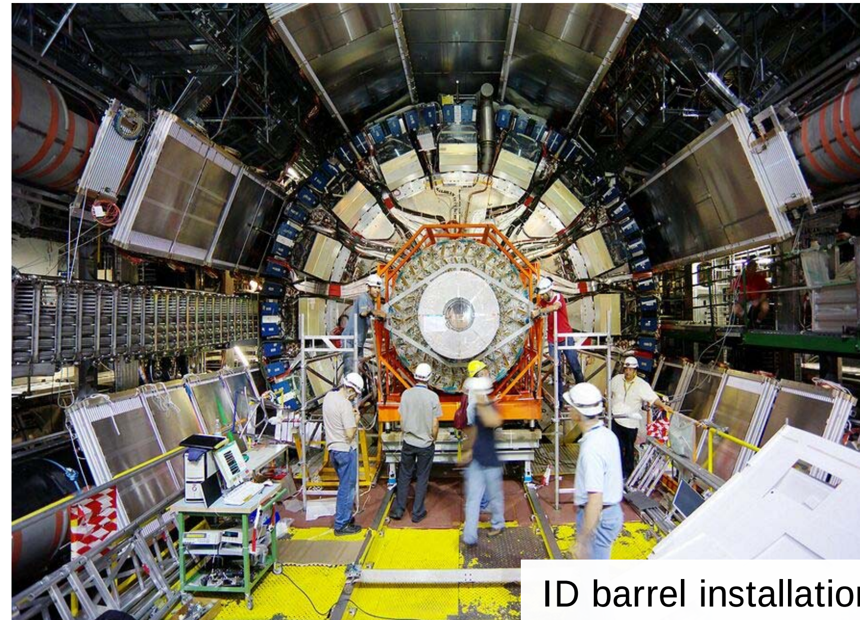
6000 fb^{-1}	S	S/B	S/$\sqrt{B}$
m_H = 170 GeV	350	8%	5.4
m_H = 200 GeV	220	7%	3.8

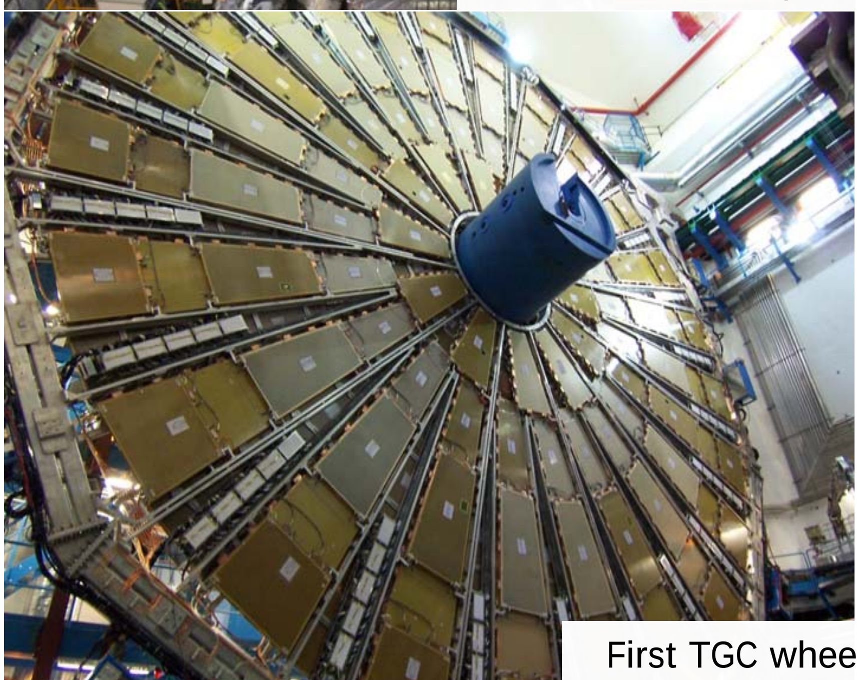
-- HH production may be observed first at SLHC: ~150 <M_H<200 GeV
-- λ may be measured with statistical error ~ 20-25%

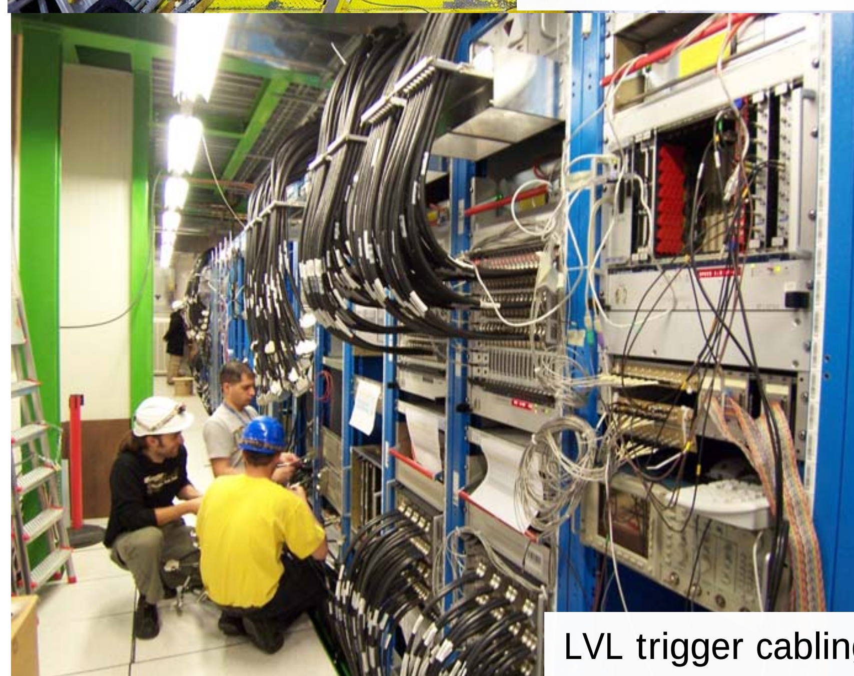
LC : precision up to 20-25% but for M_H < 150 GeV ($\sqrt{s} \geq$ 500-800 GeV, 1000 fb^{-1})

ATLAS Detector construction in UX15


All calorimeters in place

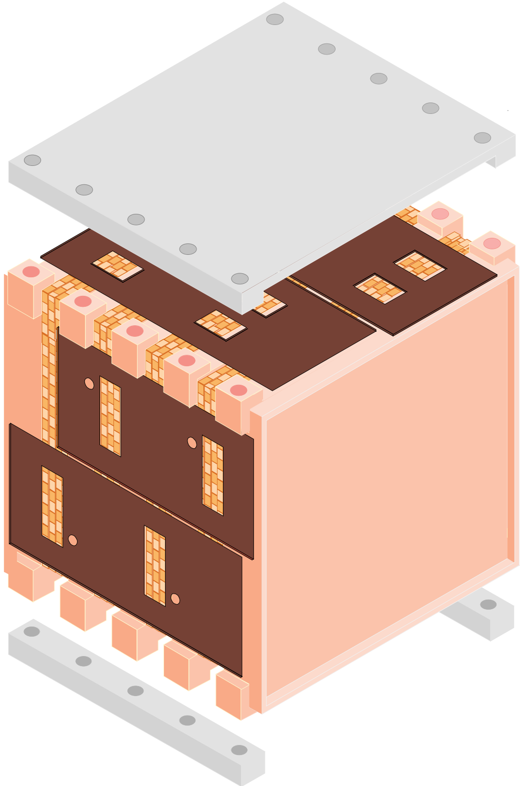

ID barrel installation


First TGC wheel


LVL trigger cabling

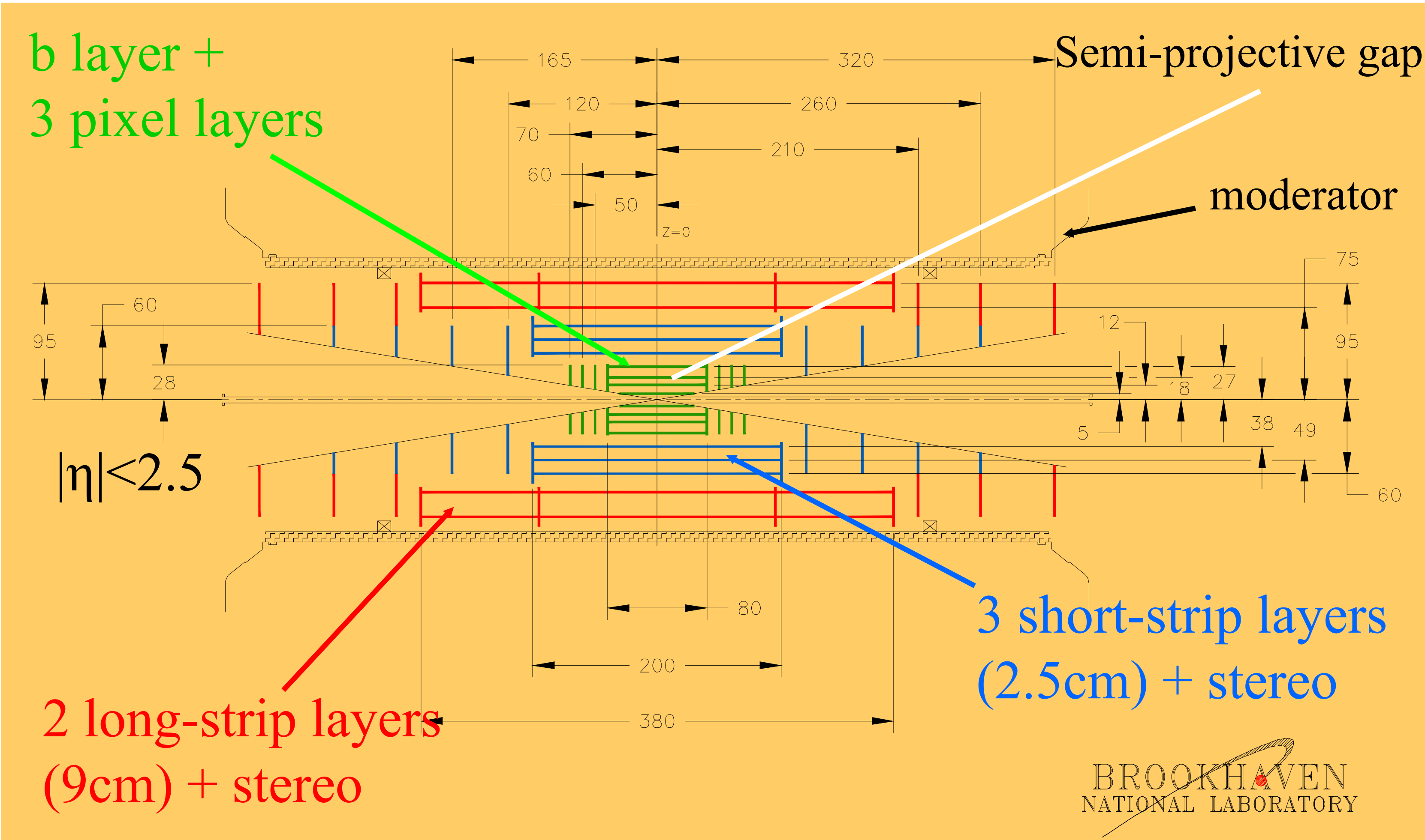
HiLum Test Modules

FCAL module



- 4 'standard' HEC gaps (HEC1)
- 4 read-out channels
- 4 HV lines (one per subgap)

Strawman Layout of Tracker



Diamond Pixel Sensor EOI

- Submitted early May
- Institutions:
  - Bonn
  - Carleton
  - CERN
  - Ljubljana
  - Ohio State
  - Toronto
- Review/approval in summer/fall

ATLAS project	Diamond Pixel Modules for the High Luminosity ATLAS Inner Detector Upgrade		
ATLAS Upgrade Document No:	*Institute Document No.*	*Created:* **11/05/2007** *Modified:*	*Page:* **1 of 12** *Rev. No.:* **1.0**

Abstract

The goal of this proposal is the development of diamond pixel modules as an option for the ATLAS pixel detector upgrade. This proposal is made possible by progress in three areas: the recent reproducible production of high quality diamond material in wafers, the successful completion and test of the first diamond ATLAS pixel module, and the operation of a diamond after irradiation to $1.8x10^{15}$ p/cm^2. In this proposal we outline the results in these three areas and propose a plan to build and characterize a number of diamond ATLAS pixel modules, test their radiation hardness, explore the cooling advantages made available by the high thermal conductivity of diamond and demonstrate industrial viability of bump-bonding of diamond pixel modules .

Contact Person: Marko Mikuž (marko.mikuz@cern.ch)

Prepared by:	*Checked by:*	*Approved by:*
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